FENOC

FirstEnergy Nuclear Operating Company

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724-682-7773

December 9, 2005
L-05-192

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: **Beaver Valley Power Station, Unit Nos. 1 and 2**
BV-1 Docket No. 50-334, License No. DPR-66
BV-2 Docket No. 50-412, License No. NPF-73
Supplemental PRA Information in Support of License Amendment Request Nos. 302 and 173, Extended Power Uprate (EPU)

License Amendment Request (LAR) Nos. 302 and 173 (Reference 1) propose an Extended Power Uprate (EPU) for Beaver Valley Power Station (BVPS) Unit Nos. 1 and 2. As a result of the NRC EPU Probabilistic Risk Assessment (PRA) audit conducted at BVPS on October 18 and 19, 2005, the following information is being provided as requested by the NRC staff reviewers. The purpose of the audit was to determine if the BVPS risk assessment was adequate to support the proposed EPU LAR, and to review the responses for Request for Additional Information (RAI) questions with respect to the EPU PRA provided in FENOC Letter L-05-140 (Reference 2).

Enclosure 1 provides updated responses to address Questions 2.c and 2.d of Reference 2, which supersede in their entirety the previous responses to Questions 2.c and 2.d of Reference 2.

Enclosure 2 provides additional information to address Question 3 of Reference 2. The information includes a sensitivity study of the Human Reliability Analysis for BVPS Unit Nos. 1 and 2 showing risk impact of EPU without crediting other changes to the PRA model. This information is intended to supplement the previous response to Question 3 of Reference 2.

No new regulatory commitments are contained in this submittal. If you have questions or require additional information, please contact Mr. Greg A. Dunn, Manager - Licensing, at 330-315-7243.

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I declare under penalty of perjury that the foregoing is true and correct. Executed on December 9, 2005.

Sincerely,

Richard G. Mende

Richard G. Mende

Enclosures:
1. Updated Responses to Address Questions 2.c and 2.d of RAI dated August 2, 2005
2. Additional Information to Address Question 3 of RAI dated August 2, 2005

References:
1. FENOC Letter L-04-125 "License Amendment Request 302 and 173", dated October 4, 2004.

2. FENOC Letter L-05-140 "Response to a Request for Additional Information (RAI dated August 2, 2005) in Support of License Amendment Request Nos. 302 and 173, Extended Power Uprate", dated September 6, 2005.

c: Mr. T. G. Colburn, NRR Senior Project Manager
Mr. P. C. Cataldo, NRC Senior Resident Inspector
Mr. S. J. Collins, NRC Region I Administrator
Mr. D. A. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

Enclosure 1 of L-05-192

Updated Responses to Address Questions 2.c and 2.d of RAI dated August 2, 2005

The following information provides updated responses to address Questions 2.c and 2.d of the NRC Request for Additional Information dated August 2, 2005. These updated responses supersede, in their entirety, those previous responses transmitted by FENOC Letter L-05-140 dated September 6, 2005.

Question 2.c:

Table 10.16-1 gives pre- and post-EPU times to core damage for station blackout scenarios. Why does this time increase on BVPS-1 and decrease on BVPS-2 for the "182 gpm, successful cooldown/depressurization, primary plant demineralized water storage tank make-up available" case?

Response to Question 2.c:

The increase in time to core damage for the BVPS-1, 182 gpm reactor coolant pump (RCP) seal LOCA with successful cooldown/depressurization and primary plant demineralized water storage tank (PPDWST) make-up available case is primarily due to changes in the initial accumulator water mass used in the Modular Accident Analysis Program (MAAP) parameter file for the pre- to post-EPU/ replacement steam generators (RSG) conditions.

For the BVPS-1 MAAP case SBO11 (182 gpm RCP seal LOCA with successful cooldown/ depressurization and PPDWST refill), two significant differences in sequence progression were noted between the pre-EPU model and the post-EPU model calculations:

1. The pressurizer drains several hours earlier in the pre-EPU model calculation.

2. Core damage occurs several hours earlier in the pre-EPU model calculations.

In contrast, for BVPS-2, the post-EPU model calculations for the same scenario indicate core damage slightly earlier than the pre-EPU model calculations.

BVPS-1 Timing Differences

Regarding the pressurizer water level, the pre-EPU model indicates that the pressurizer reaches a maximum level in about 9 hours and then drains until it is empty, which occurs in about 16 hours. The BVPS-1 post-EPU model indicates a sustained pressurizer level until approximately 17 hours (see Figure 2-1).

Regarding core damage, the post-EPU model shows a delay of approximately 3.5 hours in the time of core damage relative to the pre-EPU model calculation. Precise sequence timing for BVPS-1 MAAP case SBO11, taken from the MAAP output, is shown in Table 2-7.

Table 2-7: BVPS Unit 1 SBO11 Core Damage Timing					
Seal LOCA Leak Rate (gpm/RCP)	Time of RCS Cooldown/ Depress (minutes)	Makeup to PPDWST Available	Time To Core Damage (hours)		
			Pre-EPU model with seal binding failure at 30 minutes	Post-EPU Model with seal binding failure at 30 minutes	Post-EPU model with seal binding failure at 13 minutes
182	30	Y	27.0	30.6	30.3

Both the pressurizer draining and the timing of core damage are controlled in large part by the behavior of the accumulators (2 out of 3 assumed to inject). A key difference in design input from the pre-EPU to the post-EPU model (see Table 2-8) is the initial water mass assumed in the accumulators. Both models use accumulator inventory based on the Technical Specification minimum water volume (pre-EPU: 7664 gal; post-EPU: 6681 gal). However, the post-EPU volume is based on the Technical Specification minimum usable water volume, since about 195 gallons will remain in the tanks due to the injection nozzle location. Thus, the pre-EPU MAAP model is based on a larger initial water mass and hence a smaller pressurized gas volume, than the post-EPU MAAP model. Because of the smaller gas space, the accumulators in the pre-EPU model will tend to depressurize faster than the accumulators in the post-EPU model, thereby allowing less total injected water mass over the course of the accident.

Table 2-8: BVPS Unit 1 Summary of Design Input Changes for the MAAP Post-EPU Model		
Description	Pre-EPU Model	Post-EPU Model
Available water mass per accumulator	Tech Spec minimum: 7664 gal/ 7.481 ft^3/gal * 62.3 lb/ft^3 = 6.3824E4 lbm	Minimum usable value: 5.56E4 lbm
Accumulator nitrogen pressure	Tech Spec minimum pressure: 619.3 psia	600 psia*
Total volume per accumulator	1450 ft^3	1436 ft^3
* FENOC Letter L-05-168 dated 10/28/2005 changed the minimum accumulator nitrogen cover pressure to 611 psig. This pressure increase tends to inject more accumulator water inventory into the RCS for a given pressure, so using 600 psia is conservative for the PRA SBO success criteria analysis.		

Since the post-EPU Technical Specification minimum usable accumulator water volume (6681 gal) is significantly less than the adjusted pre-EPU Technical Specification minimum usable water volume (7664 gal –195 gal = 7469 gal), the water contained in the accumulators following the post-EPU plant changes could potentially be less than the accumulator inventory maintained currently. Therefore, when using the minimum volumes the effect of more mass injection observed in the MAAP calculations is a result of the new plant configuration and not simply a result of a change in assumptions.

Figure 2-2 compares the accumulator pressures for the BVPS-1 pre-EPU and post-EPU model calculations. As shown, accumulators for both cases depressurize to approximately the same level.

Figure 2-3 compares the available BVPS-1 accumulator water mass in two accumulators for the pre-EPU and post-EPU cases. The total injected water mass for the pre-EPU case is 53,000 lbm while the total mass injected is 70,000 lbm for the post-EPU case. Thus, due to the expansion of different initial volumes, the post-EPU case calculates 32% more accumulator mass to be injected. This result is consistent with the first principle relationship between pressure and gas volume for isothermal expansion.

Considering isothermal expansion of the accumulator gas during the blowdown, the accumulator pressure can be related to the change in gas volume as,

$$P_1/P_2 = V_2/V_1 \qquad (1)$$

Where P_1 and V_1 are the initial gas pressure and volume and P_2 and V_2 are the final gas pressure and volume. This equation can be used to derive an expression relating the gas volume change to the mass discharged during the blowdown:

$$\Delta V = \Delta M\rho = V_1(P_1/P_2 - 1) \qquad (2)$$

Where ΔV is the total gas volume change, ΔM is the water mass discharged, and ρ is the water density.

This expression shows that for a given change in pressure, the mass discharged is linearly proportional to the initial gas volume. For the pre-EPU and post-EPU models, the initial accumulator gas volumes are 427 ft^3 and 545 ft^3, respectively, thus as a result of the difference in initial gas volumes and assuming the pressure changes are identical (see Figure 2-2), the post-EPU model is expected to discharge (545/427 – 1)% = 27% more water than the pre-EPU model. This is comparable to the actual mass difference calculated by MAAP of 32%.

To further investigate the influence of the change in initial accumulator inventory, the post-EPU model case was re-run using the pre-EPU initial accumulator water mass. Figures 2-4 and 2-5 compare the modified post-EPU calculation of accumulator water mass and pressurizer level to the pre-EPU calculations. As shown, significantly better agreement is obtained. In addition, the post-EPU time to core damage decreases to 29 hours. The remaining two-hour time difference to core damage is explored further in the following section.

Secondary effects on the station blackout (SBO) sequence progression between the BVPS-1 pre-EPU and post-EPU models include a higher rate of reflux cooling and a larger initial primary system water mass for the post-EPU model. The prolonged RCS inventory loss during the SBO sequence results in separation of the primary system coolant phases. Once phase separation occurs, the primary side of the steam generator tubes is in contact primarily with steam. At this point, because turbine driven auxiliary feedwater is available, reflux condensation occurs. Figure 2-6 shows the steam condensation rate on the primary side of the steam generator tubes and is an indication of the reflux cooling. As shown, at phase separation just beyond 5 hours, a significant amount of steam condensation occurs with a slightly higher rate of condensation for the post-EPU model. Hence, a higher rate of reflux cooling takes place with the post-EPU model. In the post-EPU model MAAP calculations, the maximum time step is limited to 1 second once the primary system phases are separated. This leads to improved numerical stability and a slightly higher reflux cooling rate as compared to the pre-EPU model calculations.

Another key difference in the BVPS-1 MAAP inputs is that the initial primary system water mass (excluding the pressurizer) for the post-EPU model is 388,127 lbs. vs. 382,073 lbs. for the pre-EPU model MAAP analysis. Thus, the post-EPU model initially has about 1.5% more water mass in the primary system. This initial mass difference is due to a slightly larger primary side volume for the RSGs as compared to the original steam generators (OSG). The total primary side volume of one steam generator is 1136 ft^3 for the RSG and 1087 ft^3 for the OSG. The initial pressurizer inventory could also potentially contribute to a change in initial water mass, as well. However, for BVPS-1 the pre-EPU and post-EPU plant models both have identical initial pressurizer water masses.

Both the higher reflux cooling rate and the slightly larger initial coolant volume for the post-EPU model are positive factors that will tend to delay the onset of core damage.

BVPS-2 Timing Differences

For BVPS-2, the post-EPU model shows a slightly earlier time of core damage relative to the pre-EPU model calculation, which is the opposite trend observed for the BVPS-1 calculations. Precise sequence timing for the BVPS-2 MAAP case SBO11, taken from the MAAP output, is shown in Table 2-9.

Table 2-9: BVPS Unit 2 SBO11 Core Damage Timing

Seal LOCA Leak Rate (gpm/RCP)	Time of RCS Cooldown/ Depress (minutes)	Makeup to PPDWST Available	Time To Core Damage (hours)		
			Pre-EPU model with seal binding failure at 30 minutes	Post-EPU Model with seal binding failure at 30 minutes	Post-EPU model with seal binding failure at 13 minutes
182	30	Y	34.0	Not Analyzed	33.1

Although the trend in core damage timing is different for BVPS-2 as compared to BVPS-1, the controlling factor is the same; namely, the behavior of the accumulators has a primary influence on the time of core damage. For BVPS-2, both the pre-EPU and post-EPU calculations indicate discharge of 100% of the accumulator water inventory into the system, whereas the BVPS-1 calculations indicated only a partial injection of the accumulators. This is most likely due to the lower RCS pressures obtained during the cooldown as a result of the two steam generators required for the BVPS-2 cooldown success criteria, as opposed to only one required for BVPS-1. As shown in Table 2-10, the BVPS-2 pre-EPU initial water mass used is 62,000 lbm per accumulator while the BVPS-2 post-EPU model initial water mass is 57,400 lbm per accumulator. Thus, with 100% of the accumulator inventory injected, the pre-EPU model provides more water to the system and, as expected, indicates a later time to core damage than the BVPS-2 post-EPU model calculation. Also, with 100% accumulator injection, the BVPS-2 calculations show a later time to core damage than the corresponding BVPS-1 calculations.

Table 2-10: BVPS Unit 2 Summary of Design Input Changes for the MAAP Post-EPU Model		
Description	Pre-EPU Model	Post-EPU Model
Available water mass per accumulator	62,000 lbm	Minimum usable value: 57,400 lbm
Accumulator nitrogen pressure	645.5 psia	600 psia*
Total volume per accumulator	1450 ft^3	1436 ft^3
* *FENOC Letter L-05-168 dated 10/28/2005 changed the minimum accumulator nitrogen cover* pressure to 611 psig. This pressure increase tends to inject more accumulator water inventory into the RCS for a given pressure, so using 600 psia is conservative for the PRA SBO success criteria analysis.		

A secondary influence in the BVPS-2 calculations is the initial pressurizer water volume assumed for the calculation. The pre-EPU model uses an initial pressurizer water volume of 765 ft^3 while the post-EPU model has an initial pressurizer water volume of 834 ft^3. The larger initial pressurizer water volume for the post-EPU model will tend to offset the smaller post-EPU model accumulator inventory.

BVPS-1 vs. BVPS-2 Core Damage Timing and the Influence of Accumulators

Several sensitivity cases were run to investigate the changes in timing of core damage for BVPS1 and 2 for the pre-EPU and post-EPU plant models. These sensitivity runs indicate that the various plant models behave in similar fashion and produce consistent results when the accumulator performance is the same. That is to say, the changes in timing to core damage are *most strongly influenced by the amount and timing of accumulator water injection into the* system.

First, Figure 2-7 shows the time of core damage as a function of the amount of accumulator water injected. This information was compiled by running a series of MAAP cases in which the accumulator water mass was fixed and 100% of the accumulator inventory was allowed to inject into the system.

The case of zero accumulator inventory indicates that even without accumulators, there would be approximately 0.5 hours difference in the time to core damage for BVPS-1 between the pre-EPU and post-EPU plant models. The timing difference remains approximately constant as the injected water mass increases up to 40,000 lbm. This is an indication that large timing differences (in excess of 1 hour) are caused by differences in the amount of accumulator water injected into the system.

A second effect, just as important as the total mass injected, is the timing of the accumulator injection. For example, the sensitivity case discussed previously and presented in Figures 2-4 *and 2-5 shows that even when the pre-EPU and post-EPU models inject the same accumulator* water mass (52,800 lbm), there is still about a 2 hour difference in the time to core damage. Figure 2-8 expands the time scale for this case and indicates that near 10 hours, the post-EPU model has a late accumulator injection of an additional 5000 lbm. If the late accumulator injection is prevented by closing the accumulator block valves after 8 hours (plotted line with triangle symbols in Figure 2-8), then the core damage timing difference from the pre-EPU model to the post-EPU model is reduced to less than 1 hour (post-EPU model core damage time if late accumulator injection is prevented is 27.9 hours vs. 27.0 hours for the pre-EPU model). This timing difference is consistent with the trend presented in Figure 2-7.

Figure 2-9 compares the pressurizer water level for the pre-EPU and post-EPU model sensitivity runs. As shown, if late accumulator injection is prevented, then similar pressurizer behavior is obtained between the pre-EPU and post-EPU plant models.

The sensitivity cases presented herein indicate that the trends going from the pre-EPU model to the post-EPU model of increasing time to core damage for BVPS-1 and decreasing time to core damage for BVPS-2 is primarily a result of differences in both the total mass of accumulator water injected and the timing of the injection.

SUMMARY

In summary, the main contribution to the difference in core damage timing is the behavior of the accumulators, which is due in large part to the proposed change in Technical Specifications for accumulator water volume. The revised post-EPU Technical Specifications specifies a maximum usable accumulator water volume that is less than the current minimum contained accumulator water volume Technical Specification value. So, it is expected that there will be an actual reduction in initial accumulator water volume upon completion of the post-EPU plant modifications and that this will have a real impact on the volume injected into the RCS, thereby affecting the progression of postulated accident sequences.

Secondary influences on the calculated time to core damage for the SBO sequence are the rate of reflux cooling, which is somewhat higher in the BVPS-1 post-EPU model calculations as a result of an improved numerical calculation, and the initial RCS coolant inventories which are influenced by the BVPS-1 RSGs and assumptions of increased initial pressurizer inventory for BVPS-2.

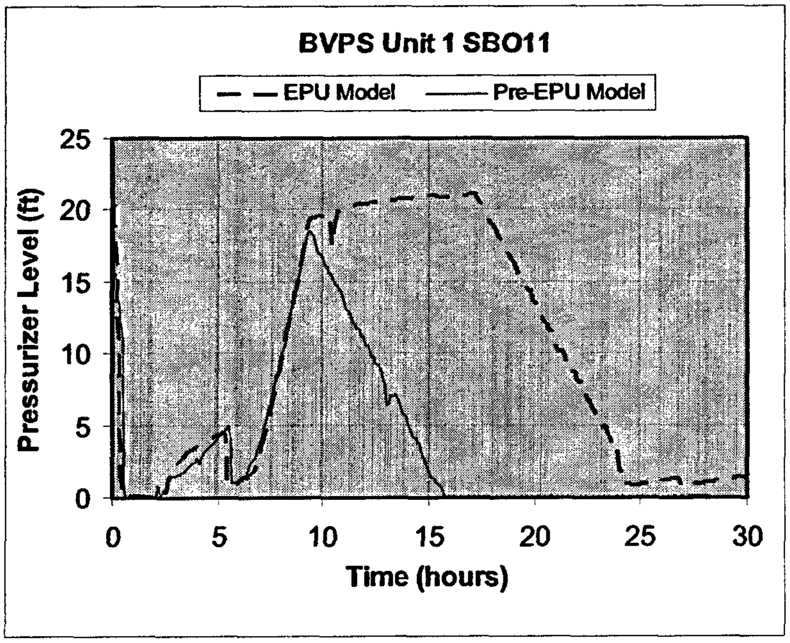

Figure 2-1: MAAP Pressurizer Water Level for Case SBO11

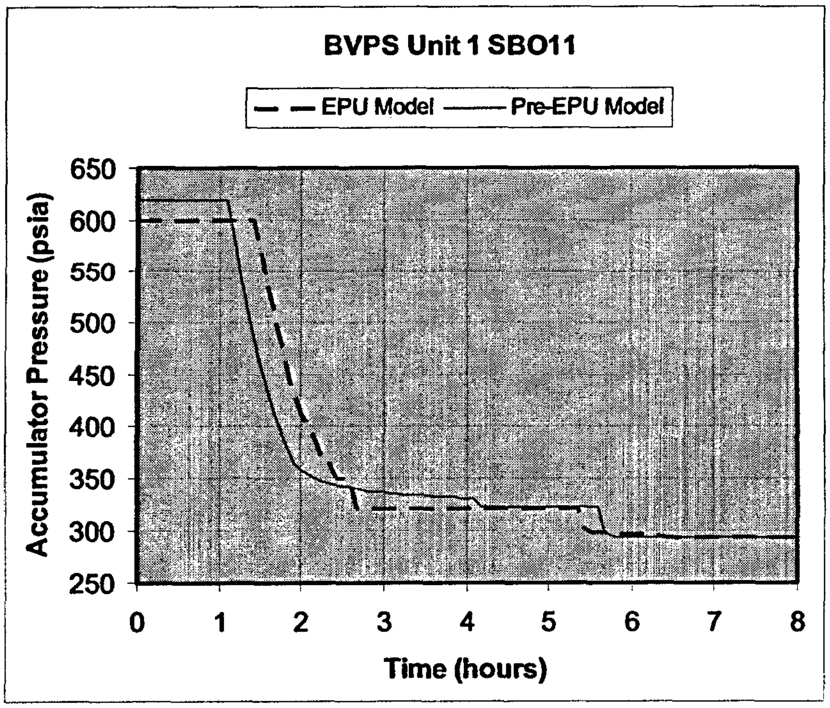

Figure 2-2: MAAP Accumulator Pressure for Case SBO11

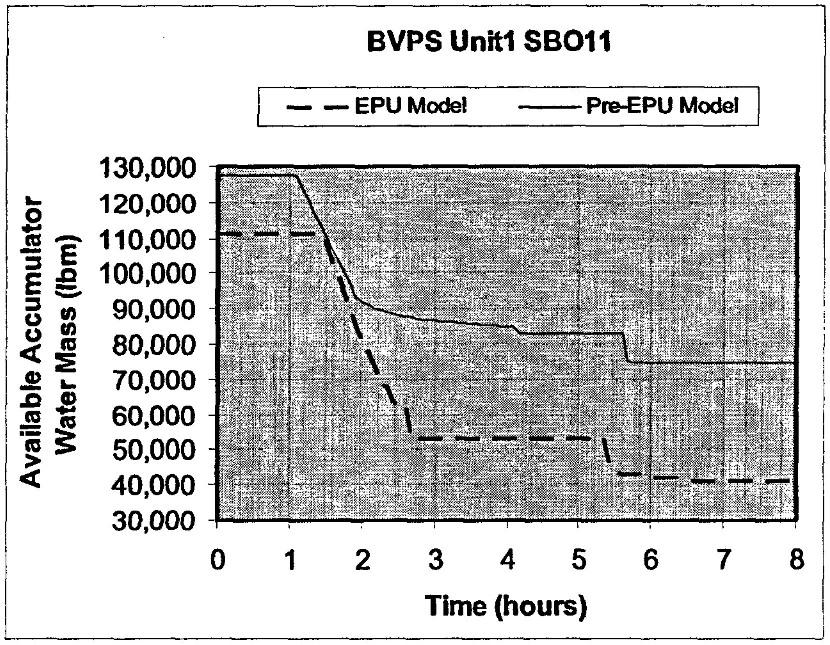

Figure 2-3: MAAP Accumulator Water Mass (2 Accumulators) for Case SBO11

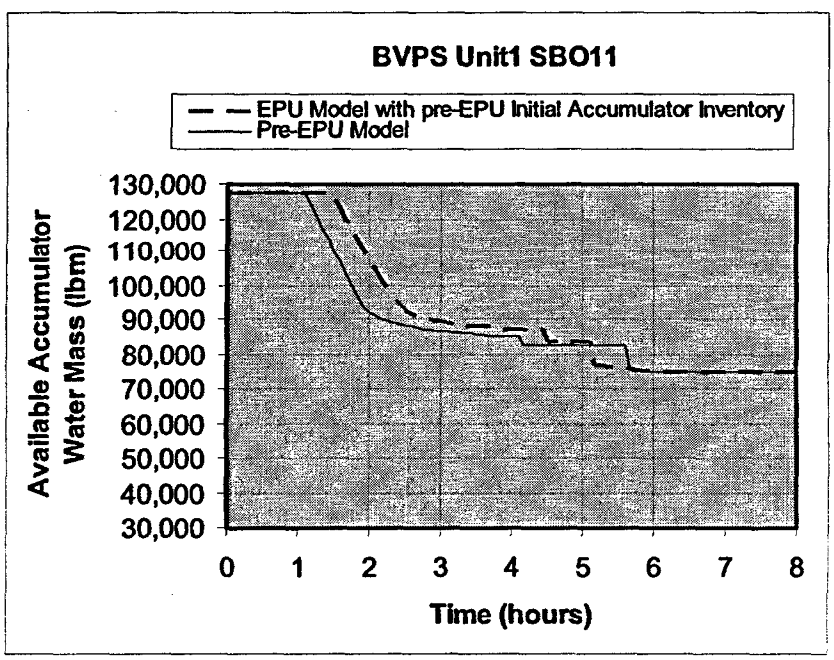

Figure 2-4: MAAP Accumulator Water Mass (2 Accumulators) for Case SBO11 with the post-EPU Initial Accumulator Inventory Set Equal to the pre-EPU Model Value

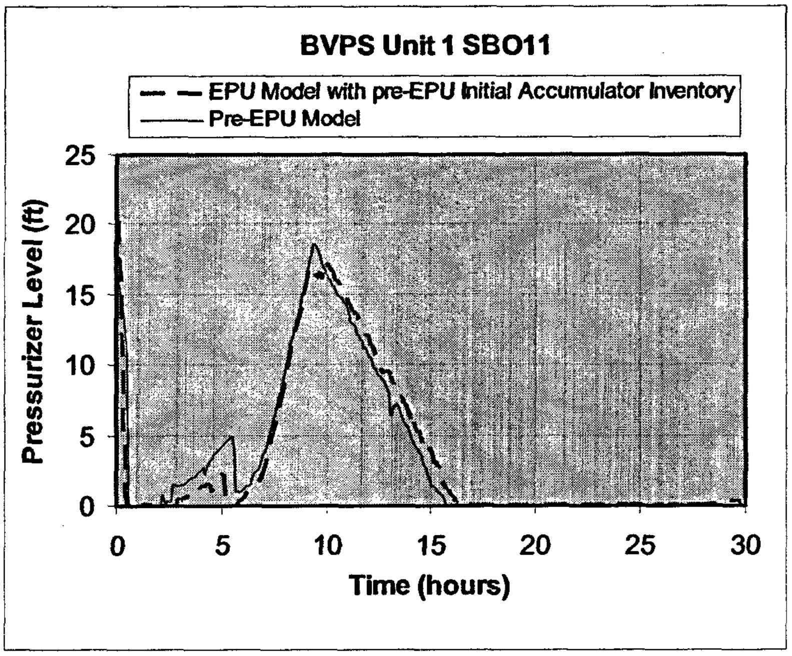

Figure 2-5: MAAP Pressurizer Level for Case SBO11 with the post-EPU Initial Accumulator Inventory Set Equal to the pre-EPU Model Value

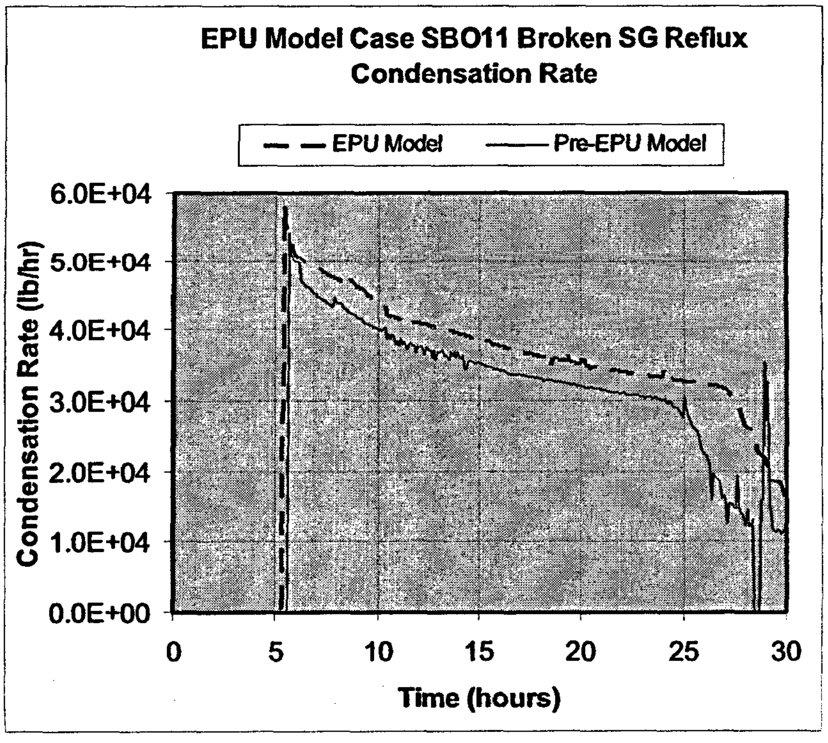

Figure 2-6: MAAP Reflux cooling for Case SBO11

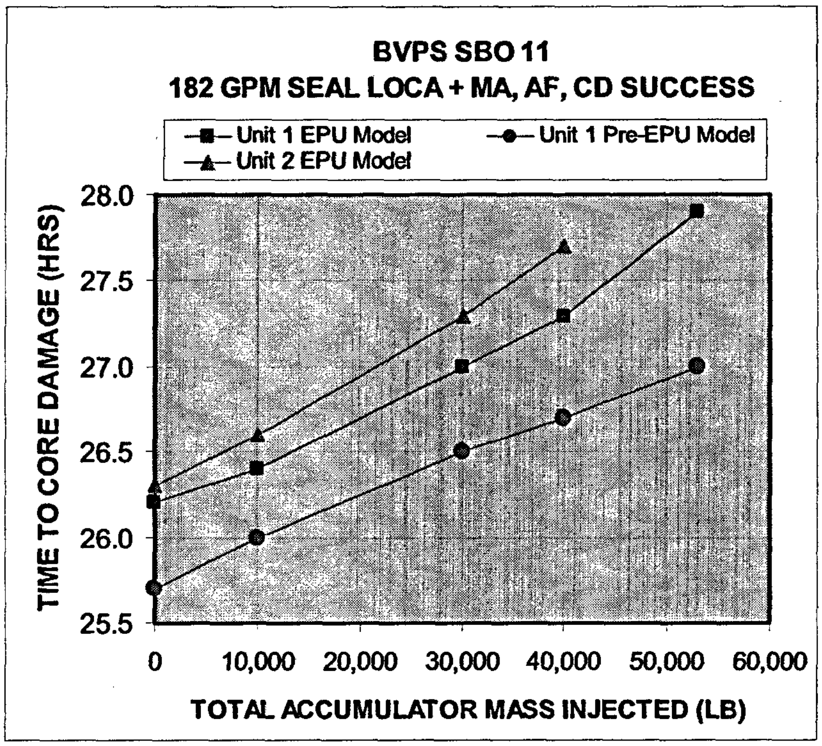

Figure 2-7: Core Damage Timing as a Function of Injected Accumulator Water

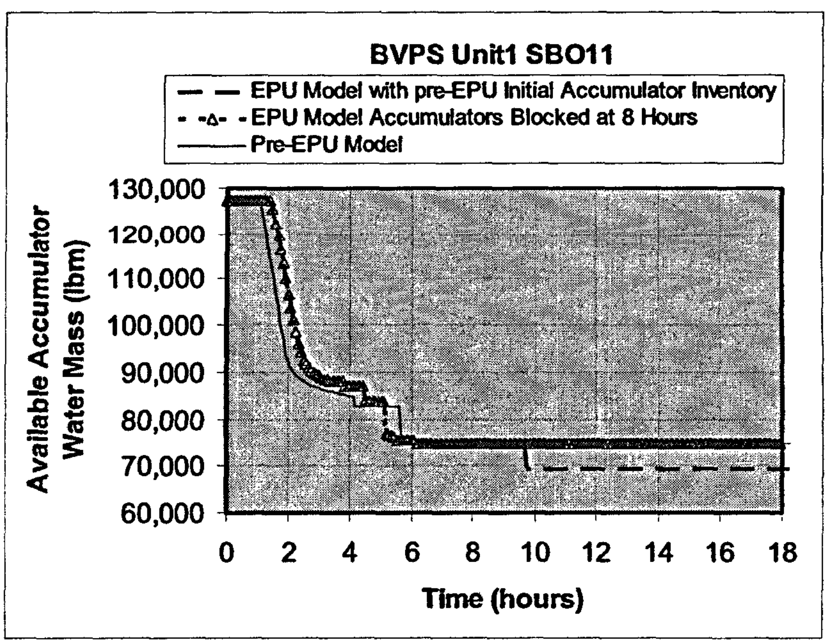

Figure 2-8: BVPS Unit 1 SBO11 Accumulator Water Mass for post-EPU and Pre-EPU Models

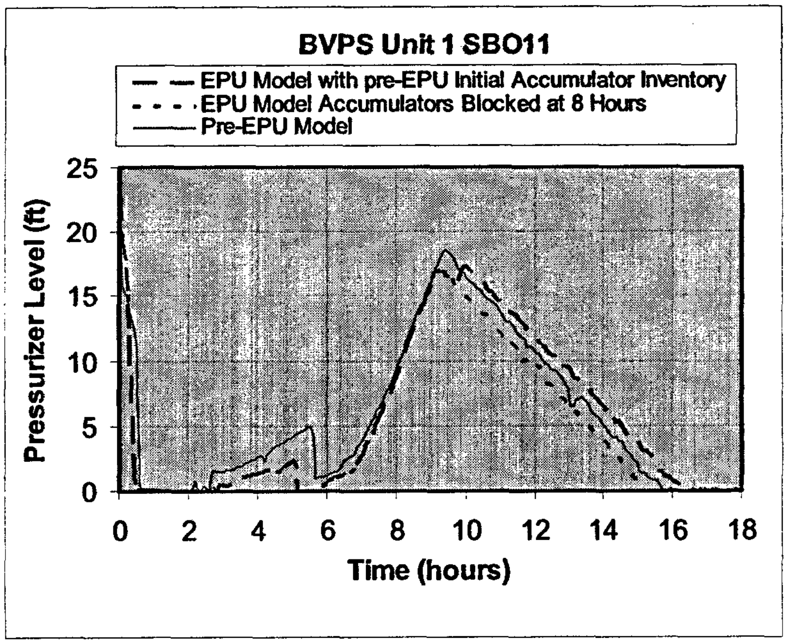

Figure 2-9: BVPS Unit 1 SBO11 Pressurizer Level for post-EPU and Pre-EPU Models

Question 2.d.

Under the discussion of "general transients," it states: "Thus, with the RSG [replacement steam generators] there is less margin for successful completion of the plant-specific feed and bleed procedure ... initiated at 0.495 hours ...." Does the time available for this action change under EPU conditions? What is the human error probability (HEP) for this action, both pre- and post-EPU? Why was this action not included in Table 10.16-2 or 10.16-5?

Response to Question 2.d.

The general transient success criteria discussion presented in LAR 1A-302 & 2A-173, L-05-104 was based on a loss of all feedwater (both main and auxiliary), with credit for operators to initiate feed and bleed at 13% wide range steam generator (SG) level per the current plant procedures. This stemmed from a Westinghouse Owner's Group issue regarding the required component success criteria for feed and bleed implementation (e.g., number of PORVs and HHSI pumps). To address this concern for EPU conditions, a BVPS-1 MAAP analysis was performed assuming that one HHSI pump injects and one PORV was opened once the SG reached the 13% wide range level, which occurred at 0.495 hours with the RCPs operating. The results of this analysis showed that even at EPU conditions the feed and bleed component success criteria did not change from the current plant model (i.e., one HHSI pump and one PORV). Because the BVPS-1 RSGs had less inventory remaining at the 13% wide range level than the BVPS-2 original steam generators and because the BVPS-1 pressurizer PORV capacity is less than the BVPS- 2 capacity, the BVPS-1 transient was considered bounding for BVPS-2, so the same success criteria apply.

The timing used for the operator action to initiate feed and bleed developed for the human reliability analysis (HRA) was based on the maximum time that operators have available in order to successfully implement feed and bleed. In the thermal-hydraulic hand calculations developed for the Individual Plant Examination (IPE) human action accident scenarios, the time for feed and bleed implementation was based on the time for the PORVs to lift prior to steam generator dryout. This was estimated to occur 5 minutes prior to dryout, or at about 58 minutes following a reactor trip, which was the timing used in the pre-EPU feed and bleed HRA.

In the LAR submittal, this 58-minute timing was compared to similar post-EPU MAAP analyses (a station blackout scenario with a 21 gpm RCP seal LOCA and loss of all auxiliary feedwater), that had corresponding times of 63 minutes at BVPS-1 and 65 minutes at BVPS-2. Since the pre-EPU time value bounded the post-EPU time, the HEPs used in the current pre-EPU PRA models were considered to be bounding so the values were not changed for the post-EPU analysis. As such, Tables 10.16-2 and 10.16-5, which listed operator actions that have changed for the EPU analyses, did not include these actions.

During the NRC EPU PRA audit conducted at BVPS on October 18 and 19, 2005, these post-EPU MAAP analyses were revisited, and it was noted that a station blackout scenario with a 21 gpm RCP seal LOCA and loss of all auxiliary feedwater, may not be the limiting transient, since the reactor and RCPs are tripped as part of the initiating event. Additionally, the BVPS-1 draft emergency operating procedures (EOPs) for post-EPU/RSG conditions were developed, subsequent to the LAR post-EPU MAAP analyses, which revised the EOP entry and feed and bleed implementation setpoints.

With the revised post-EPU EOPs, the entry conditions will be met once all three SGs reach the 31% narrow range level; and feed and bleed cooling will be implemented when the SGs reach the 14% wide range level in two of three steam generators. Based on these revised setpoints and initiating event, new BVPS-1 MAAP analyses were performed using a loss of all feedwater initiating event to determine the post-EPU feed and bleed component success criteria and timings used to evaluate operator actions OPROB1 and OPROB2. These BVPS-1 analyses are still considered to be bounding for BVPS-2, based on pressurizer PORV capacities.

The following provide descriptions of the operator actions and summaries of the revised MAAP cases and results for these new post-EPU/RSG condition analyses. Table 2-11 provides a listing of the significant times from the MAAP results for these cases.

OPROB1 – Given a complete loss of secondary heat removal, operators initiate feed and bleed by initiating safety injection, opening the PORVs, opening the PORV block valves (if needed), and verifying HHSI flow. Prior to these specific actions necessary to establish bleed and feed, the operators will have successfully stopped the RCPs as per EOP FR-H.1. However, operator attempts to restore auxiliary or main feedwater (or dedicated AFW at BVPS-1) are unsuccessful due to equipment failures; i.e., the operator did correctly decide to try to restore feedwater per procedures (Top Event OF was successful).

OPROB2 - Given a complete loss of secondary heat removal, operators initiate feed and bleed by stopping the RCPs, initiating safety injection, opening the PORVs, opening the PORV block valves (if needed), and verifying HHSI flow. Prior operator attempts to restore auxiliary or main feedwater (or dedicated AFW at BVPS-1) are unsuccessful; i.e., the equipment was available, but the operators failed to reestablish them in time (Top Event OF has failed). In addition, operator actions to trip the RCPs prior to feed and bleed entry conditions were not completed.

Cases 1A and 1B are base case evaluations to determine the bounding post-EPU component success criteria (e.g., one HHSI pump and one PORV) assuming that feed and bleed cooling is implemented according to the revised EOP setpoints.

Case 1A: SUCCESS

Base case for operator action OPROB1. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes, and the RCPs are assumed to be tripped 5 minutes afterwards (5.7 min.). The feed and bleed entry conditions are met (SGs < 14% wide range level) in 10.4 minutes, at which time safety injection is manually actuated using a single HHSI pump and a single PORV is manually opened. The steam generators boil dry in 119.9 minutes, but the core remains covered and no core damage occurs.

The results of this analysis show that even at EPU conditions, if the operators trip the RCPs within 5.7 minutes following a total loss of feedwater, and feed and bleed is implemented according to the revised EOP setpoints, the component success criteria does not change from the current plant model (i.e., one HHSI pump and one PORV).

Case 1B: SUCCESS

Base case for operator action OPROB2. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes; however, the RCPs are not tripped 5 minutes afterwards. The feed and bleed entry conditions are met (SGs < 14% wide range level) in 8.5 minutes, at which time the RCPs are tripped, safety injection is manually actuated using a single HHSI pump, and a single PORV is manually opened. The steam generators boil dry in 118.9 minutes, but the core remains covered and no core damage occurs.

The results of this analysis show that even at EPU conditions, if the operators wait until feed and bleed cooling is implemented according to the revised EOP setpoints to trip the RCPs, the component success criteria does not change from the current plant model (i.e., one HHSI pump and one PORV).

Cases 2A and 2B are sensitivity evaluations to determine if the post-EPU component success criteria determined in Cases 1A and 1B (i.e., one HHSI pump and one PORV) would be successful if the operators waited until 58 minutes before implementing feed and bleed cooling. This timing of 58 minutes is the maximum timing used to develop the BVPS-2 pre-EPU human error probabilities for the operator actions to initiate feed and bleed. At BVPS-1 a similar time of 57 minutes was estimated, so 58 minutes was used as the maximum bounding time in the MAAP post-EPU re-analyses.

Case 2A: FAILURE

Sensitivity case for operator action OPROB1 to determine if a single HHSI pump and a single PORV are successful at providing feed and bleed cooling if implemented in 58 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes, and the RCPs are assumed to be tripped 5 minutes afterwards (5.7 min.). The feed and bleed actions are implemented at 58 minutes, at which time safety injection is manually actuated using a single HHSI pump and a single PORV is manually opened. The steam generators boil dry in 62.4 minutes, the core uncovers in 82.2 minutes, and core damage occurs at 105.7 minutes.

The results of this analysis show that at EPU conditions, if the operators trip the RCPs within 5.7 minutes following a total loss of feedwater, but wait until 58 minutes before feed and bleed is implemented, the component success criteria of one HHSI pump and one PORV are insufficient in order to prevent core damage.

Case 2B: FAILURE

Sensitivity case for operator action OPROB2 to determine if a single HHSI pump and a single PORV are successful at providing feed and bleed cooling if implemented in 58 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes; however, the RCPs are not tripped 5 minutes afterwards. The feed and bleed actions are implemented at 58 minutes, at which time the RCPs are tripped, safety injection is manually actuated using a single HHSI pump, and a single PORV is manually opened. The steam generators boil dry in 26.3 minutes, the core uncovers in 59.6 minutes, and core damage occurs at 82.8 minutes.

The results of this analysis show that at EPU conditions, if the operators wait to trip the RCPs and implement feed and bleed cooling until 58 minutes following the loss of all feedwater, the component success criteria of one HHSI pump and one PORV are insufficient in order to prevent core damage.

Cases 3A and 3B are also sensitivity evaluations based on 58 minutes to implement feed and bleed cooling and are similar to Cases 2A and 2B except that the component success criteria is for opening two PORVs instead of one.

Case 3A: SUCCESS

Sensitivity case for operator action OPROB1 to determine if a single HHSI pump and two PORVs are successful at providing feed and bleed cooling if implemented in 58 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes, and the RCPs are assumed to be tripped 5 minutes afterwards (5.7 min.). The feed and bleed actions are implemented at 58 minutes, at which time safety injection is manually actuated using a single HHSI pump and two PORVs are manually opened. The steam generators boil dry in 62.5 minutes and the core uncovers in 78.0 minutes; however, no core damage occurs.

The results of this analysis show that at EPU conditions, if the operators trip the RCPs within 5.7 minutes following a total loss of feedwater, but wait until 58 minutes before feed and bleed is implemented, the component success criteria of one HHSI pump and two PORVs are sufficient for preventing core damage.

Case 3B: SUCCESS

Sensitivity case for operator action OPROB2 to determine if a single HHSI pump and two PORVs are successful at providing feed and bleed cooling if implemented in 58 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes; however, the RCPs are not tripped 5 minutes afterwards. The feed and bleed actions are implemented at 58 minutes, at which time the RCPs are tripped, safety injection is manually actuated using a single HHSI pump, and two PORVs are manually opened. The steam generators boil dry in 26.3 minutes and the core uncovers in 58.9 minutes; however no core damage occurs.

The results of this analysis show that at EPU conditions, if the operators wait to trip the RCPs and implement feed and bleed cooling until 58 minutes following the loss of all feedwater, one HHSI pump and two PORVs are sufficient for preventing core damage.

Since Cases 2A and 2B were unsuccessful at preventing core damage, if feed and bleed was implemented at 58 minutes, using the current component success criteria of one HHSI pump and one PORV at post-EPU conditions, the remaining cases were performed to determine what the maximum time available would be in order for the operators to successfully implement feed and bleed cooling.

Case 4A: FAILURE

Sensitivity case for operator action OPROB1 to determine if a single HHSI pump and a single PORV are successful at providing feed and bleed cooling if implemented in 43 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes, and the RCPs are assumed to be tripped 5 minutes afterwards (5.7 min.). The feed and bleed actions are implemented at 43 minutes, at which time safety injection is manually actuated using a single HHSI pump and a single PORV is manually opened. The steam generators boil dry in 66.5 minutes, the core uncovers in 94.7 minutes, and core damage occurs at 123.2 minutes.

The results of this analysis show that at EPU conditions, if the operators trip the RCPs within 5.7 minutes following a total loss of feedwater, and implement feed and bleed cooling at 43 minutes, the component success criteria of one HHSI pump and one PORV are insufficient in order to prevent core damage.

Case 5A: SUCCESS

Sensitivity case for operator action OPROB1 to determine if a single HHSI pump and a single PORV are successful at providing feed and bleed cooling if implemented in 42 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes, and the RCPs are assumed to be tripped 5 minutes afterwards (5.7 min.). At 10.4 minutes the feed and bleed entry conditions are met (SGs < 14% wide range level), but the actions are not implemented. At 42 minutes, the feed and bleed actions are implemented, at which time safety injection is manually actuated using a single HHSI pump and a single PORV is manually opened. The steam generators boil dry in 67.1 minutes and the core uncovers in 95.6 minutes; however, no core damage occurs.

The results of this analysis show that at EPU conditions, if the operators trip the RCPs within 5.7 minutes following a total loss of feedwater, and implement feed and bleed cooling at 42 minutes, one HHSI pump and one PORV are sufficient for preventing core damage.

Case 4B: FAILURE

Sensitivity case for operator action OPROB2 to determine if a single HHSI pump and a single PORV are successful at providing feed and bleed cooling if implemented in 30 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes; however, the RCPs are not tripped 5 minutes afterwards. The feed and bleed actions are implemented at 30 minutes, at which time the RCPs are tripped, safety injection is manually actuated using a single HHSI pump, and a single PORV is manually opened. The steam generators boil dry in 26.3 minutes, the core uncovers in 85.4 minutes, and core damage occurs at 113.4 minutes.

The results of this analysis show that at EPU conditions, if the operators trip the RCPs and implement feed and bleed cooling 30 minutes following the loss of all feedwater, the component success criteria of one HHSI pump and one PORV are insufficient in order to prevent core damage.

Case 5B: SUCCESS

Sensitivity case for operator action OPROB2 to determine if a single HHSI pump and a single PORV are successful at providing feed and bleed cooling if implemented in 29 minutes. A total loss of main feedwater occurs at time zero coincident with a failure of auxiliary feedwater. A reactor trip occurs at 35.4 seconds from a reactor protection signal. The EOP for loss of secondary heat removal FR-H.1 entry conditions are met (all SGs < 31% narrow range level) in 0.7 minutes; however, the RCPs are not tripped 5 minutes afterwards. At 8.5 minutes the feed and bleed entry conditions are met (SGs < 14% wide range level), but the actions are not implemented. At 29 minutes, the feed and bleed actions are implemented, at which time the RCPs are tripped, safety injection is manually actuated using a single HHSI pump, and a single PORV is manually opened. The steam generators boil dry in 26.3 minutes and the core uncovers in 87.4 minutes; however no core damage occurs.

The results of this analysis show that at EPU conditions, if the operators trip the RCPs and implement feed and bleed cooling 29 minutes following the loss of all feedwater, one HHSI pump and one PORV are sufficient for preventing core damage.

Table 2-11: MAAP Results for Post-EPU Feed and Bleed Cases

BVPS-1 TOTAL LOSS OF ALL FEEDWATER AT TIME = 0, RCPS TRIPPED 5 MIN AFTER ENTRY INTO FR-H.1					
OPROB1	CASE 1A	CASE 2A	CASE 3A	CASE 4A	CASE 5A
# OF HHSI PUMPS	1	1	1	1	1
# OF PORVS	1	1	2	1	1
REACTOR TRIP (S)	35.4	35.4	35.4	35.4	35.4
EOP ENTRY 31% NR SG (M)	0.7	0.7	0.7	0.7	0.7
TRIP RCPS (M)	5.7	5.7	5.7	5.7	5.7
F&B ENTRY 14% WR SG (M)	10.4	10.4	10.4	10.4	10.4
IMPLEMENT F&B (M)	10.4	58.0	58.0	43.0	42.0
CIA SIGNAL (M)	48.1	67.9	61.4	61.4	61.0
SG DRYOUT (M)	119.9	62.4	62.5	66.5	67.1
CORE UNCOVERY (M)	N/A	82.2	78.0	94.7	95.6
CORE DAMAGE (M)	N/A	105.7	N/A	123.2	N/A
	SUCCESS	FAILURE	SUCCESS	FAILURE	SUCCESS
F&B ENTRY CONDITION MET (M)	10.4	10.4	10.4	10.4	10.4
F&B IMPLEMENTED (M)	10.4	58.0	58.0	43.0	42.0
TIME TO COMPLETE ACTONS (M)	-	47.6	47.6	32.6	31.6
BVPS-1 TOTAL LOSS OF ALL FEEDWATER AT TIME = 0, RCPS TRIPPED DURING FEED & BLEED ACTIONS					
OPROB2	CASE 1B	CASE 2B	CASE 3B	CASE 4B	CASE 5B
# OF HHSI PUMPS	1	1	1	1	1
# OF PORVS	1	1	2	1	1
REACTOR TRIP (S)	35.4	35.4	35.4	35.4	35.4
EOP ENTRY 31% NR SG (M)	0.7	0.7	0.7	0.7	0.7
F&B ENTRY 14% WR SG (M)	8.5	8.5	8.5	8.5	8.5
TRIP RCPS (M)	8.5	58.0	58.0	30.0	29.0
IMPLEMENT F&B (M)	8.5	58.0	58.0	30.0	29.0
CIA SIGNAL (M)	46.2	N/A	N/A	50.6	50.8
SG DRYOUT (M)	118.9	26.3	26.3	26.3	26.3
CORE UNCOVERY (M)	N/A	59.6	58.9	85.4	87.4
CORE DAMAGE (M)	N/A	82.8	N/A	113.4	N/A
	SUCCESS	FAILURE	SUCCESS	FAILURE	SUCCESS
F&B ENTRY CONDITION MET (M)	8.5	8.5	8.5	8.5	8.5
F&B IMPLEMENTED (M)	8.5	58.0	58.0	30.0	29.0
TIME TO COMPLETE ACTONS (M)	-	49.5	49.5	21.5	20.5

SUMMARY

Based on Case 5A, the maximum time available for the operators to successfully implement post-EPU feed and bleed cooling using one HHSI pump and one PORV, given that they initially trip the RCPs within 5.7 minutes following a total loss of feedwater in accordance with the revised post-EPU EOPs, is 42 minutes. If one HHSI pump and two PORVs are opened, this time can be extended to 58 minutes and still be successful; however, this would require a change in the component success criteria modeled in Top Event OB (Feed and Bleed Cooling). Therefore, 42 minutes was used to reassess the post-EPU HRA by modifying the timing performance shaping factor (PSF) used in the success likelihood index methodology (SLIM) process and recalculating the human error probabilities for operator actions OPROB1.

At BVPS-1, the timing performance shaping factor used to assess the pre-EPU operator action OPROB1 was initially assigned a value of 1 (based on 57 minutes for pre-EPU conditions). This PSF value was also deemed to be appropriate for the pre-EPU sensitivity case. In order to assess operator action OPROB1 for BVPS-1 post-EPU conditions based on 42 minutes, the timing performance shaping factor used in the SLIM process was changed from a value of 1 to a 2, to show a decrease, but still adequate time to accomplish the actions. This judgment was based on more than 31 minutes available from the time that the EOP feed and bleed setpoint is reached (at 10.4 minutes) until the time when operators actually perform the actions (at 42 minutes).

At BVPS-2, the timing performance shaping factor used to assess the pre-EPU operator action OPROB1 was initially assigned a value of 7 (based on 58 minutes for pre-EPU conditions). However, upon further review and comparisons with the same operator actions reevaluated using the EPRI HRA calculator, a PSF value of 1 for the pre-EPU sensitivity case (similar to BVPS-1) was deemed more appropriate. For BVPS-2 post-EPU conditions, a value of 2 was also used for the SLIM timing performance shaping factor to assess OPROB1, based on the adequate time available to accomplish the actions.

Based on Case 5B, the maximum time available for the operators to successfully trip the RCPs and implement post-EPU feed and bleed cooling using one HHSI pump and one PORV following a total loss of feedwater is 29 minutes. If one HHSI pump and two PORVs are opened, this time can be extended to 58 minutes and still be successful; however, this would require a change in the component success criteria modeled in Top Event OB (Feed and Bleed Cooling). Therefore, 29 minutes was used to reassess the post-EPU HRA by modifying the timing performance shaping factors used in the SLIM process and recalculating the human error probabilities for operator actions OPROB2.

At BVPS-1, the timing performance shaping factor used to assess the pre-EPU operator action OPROB2 was initially assigned a value of 1 (based on 57 minutes for pre-EPU conditions). However, upon further review a PSF value of 2 for the pre-EPU sensitivity case was deemed more appropriate. For BVPS-1 post-EPU conditions, even though the operator actions have to be implemented in 29 minutes as opposed to 57 minutes for pre-EPU conditions, there is still enough time to complete the actions carefully and methodically, so a value of 3 for the SLIM timing performance shaping factor was used to assess OPROB2. This judgment was based on more than 20 minutes available from the time that the EOP feed and bleed setpoint is reached (at 8.5 minutes) until the time when operators actually perform the actions (at 29 minutes).

At BVPS-2, the timing performance shaping factor used to assess the pre-EPU operator action OPROB2 was initially assigned a value of 7 (based on 58 minutes for pre-EPU conditions). However, upon further review and comparisons with the same operator actions reevaluated using the EPRI HRA calculator, a PSF value of 2 was deemed more appropriate. For BVPS-2 post-EPU conditions, a value of 3 for the SLIM timing performance shaping factor was also used to assess OPROB2, based on the adequate time available to accomplish the actions.

In conclusion, the feed and bleed cooling human error probabilities used in the pre-EPU sensitivity and post-EPU RAI PRA models are provided in Table 2-12. These values are also reflected in the revised response to RAI Question 3 (Tables 3-6 and 3-7), which list operators actions that have changed for the EPU analyses.

Table 2-12: Feed and Bleed Operator Action Human Error Probabilities

Description	Operator Action OPROB1	Operator Action OPROB2
BVPS-1 Pre-EPU	1.22E-03	1.53E-02
BVPS-1 Post-EPU	1.37E-03	1.68E-02
BVPS-2 Pre-EPU	1.87E-03	2.49E-02
BVPS-2 Post-EPU	2.15E-03	2.71E-02

Enclosure 2 of L-05-192

Additional Information to Address Question 3 of RAI dated August 2, 2005

The following provides additional information to address Question 3 of the NRC Request for Additional Information dated August 2, 2005. The information includes a sensitivity study of the Human Reliability Analysis for BVPS Unit Nos. 1 and 2 showing risk impact of EPU without crediting other changes to the PRA model. This information is intended to supplement our previous response to Question 3 transmitted by FENOC Letter L-05-140.

Question 3:

Please provide an assessment of the increase in risk if only the EPU is considered. For example, the impact of containment conversion, BVPS-1 replacement steam generators, BVPS-1 AFW cavitating venturis and MFW fast-acting isolation valves should not be included unless they are required for the EPU. Note that this can be done either by having non-EPU changes in both the base model and the post-EPU model or in neither.

The NRC staff would prefer that this assessment use realistic HEPs for both the pre-EPU and post-EPU analysis (where these would change) to avoid masking of the actual change in risk; refer to question 2, above. However, if bounding HEP numbers are employed, justify that the final risk metric is bounding with respect to those HEPs.

The following risk metrics should be provided for both BVPS-1 and 2:

Internal events core damage frequency (CDF) and LERF.

CDF and LERF from internal fires.

Response to Question 3:

As noted in Section 1.1.2 of Enclosure 2 of LAR 302 & 173, L-04-125, the principal modifications planned to support implementation of the EPU LAR analyses include:

Containment conversion from a sub-atmospheric to an atmospheric design basis including related modifications such as the addition of (fast-acting) feedwater isolation valves and auxiliary feedwater flow limiting (cavitating) venturis for BVPS-1

Replacement charging/safety injection pump rotating assemblies

Replacement steam generators for BVPS-1

Since the above modifications are required to support the EPU, they were considered necessary and either explicitly or implicitly included in the EPU LAR risk analysis (as addressed in the response to RAI Question 1.b) in order to accurately determine the risk impact associated with the EPU. However, in an effort to assess the impact on risk for this RAI question, only the EPU is considered, and the impact of the above EPU associated modifications were excluded.

Background

Several Probabilistic Risk Assessment (PRA) models were used to support the Beaver Valley Power Station Unit 1 (BVPS-1) and Unit 2 (BVPS-2) Extended Power Uprate. First, the current models, BV1REV3 and BV2REV3D, serve as the "base case" for which a comparison may be made to the EPU models. These models contain a Human Reliability Analysis (HRA) based on simplified hand calculations of operator action timings.

There were two stages to develop the EPU models. To support the June 2005 EPU submittal, PRA models BV1EPU and BV2EPU were created (Reference 1) to evaluate EPU conditions for BVPS-1 and BVPS-2, respectively. These models included plant modifications related to EPU, as well as the EPU associated containment conversion and replacement steam generators (RSG) (BVPS-1 only). In performing the HRA for the EPU, human error probabilities (HEP) were updated using best-estimate operator action timings, generated by the MAAP software, when the results yielded a decrease in operator action times. If the MAAP software generated operator action timings that resulted in an increase, then the original, simplified timings were maintained. The logic behind this decision is that the results would yield a bounding estimate of the increase in risk due to human error. Thus, the EPU model HRA became a mixture of simplified and best-estimate HEPs. Other non-EPU related modifications were considered in the PRA models, such as using the Westinghouse Owner's Group (WOG) 2000 Reactor Coolant Pump (RCP) seal LOCA (Loss-of Coolant Accident) model, and containment isolation signal B (CIB) setpoint reset. These changes were made to reflect how BVPS-1 and BVPS-2 are expected to be operated at the time of EPU implementation. The results of BV1EPU and BV2EPU were compared to BV1REV3 and BV2REV3D baseline models to determine a change in risk.

Additionally, in response to RAIs received on the EPU submittal, the BV1EPU and BV2EPU models were modified to create the BV1RAI and BV2RAI models for BVPS-1 and BVPS-2, respectively (Reference 2). In addition to eliminating the non-EPU related modifications mentioned above, the HRA was revisited. This time using only best-estimate operator action timings, as generated by the MAAP software, regardless of whether or not the timing resulted in an HEP increase or decrease relative to the BV1REV3 and BV2REV3D baseline models. As the best-estimate timings often produced HEPs that were lower than those produced by the simplified calculations in the "base case" models (i.e., the MAAP analysis resulted in an increase in time available, when compared to the simplified calculations). It became apparent that it was incorrect to compare the different methodologies. As a result, a realistic change in Core Damage Frequency (CDF) and Large Early Release Frequency (LERF) was not obtained.

In response to questions raised during the NRC EPU PRA Audit in October 2005, a sensitivity study was performed in support of the BVPS-1 and BVPS-2 Extended Power Uprate Risk Assessment to determine a better comparison of the change in risk due to the BVPS-1 and BVPS-2 EPU. The "base case" PRA models (BV1REV3 and BV2REV3D) use simplified thermal-hydraulic hand calculations to determine the operator action time available, while the analysis for the EPU RAI used best-estimate MAAP analyses to determine the operator action time available. In order to determine a better comparison of the change in risk due to the EPU, the "base case" PRA models were modified to include recalculated HEPs, using best-estimate operator action times available based on MAAP results. These modified baseline PRA models are hereby referred to as the sensitivity models.

Methodology

In order to limit the amount of recalculated HEPs, a screening process was developed to eliminate those operator actions that would not significantly impact the results. Since the purpose of the sensitivity model is to show that the resultant CDF would be lower than the "base case" CDF if the HEPs were recalculated using best-estimate operator action times based on MAAP results, Fussell-Vesely (F-V) importance values were used. The operator action F-V importance can provide a measure of the percent change in CDF due to a change in the HEP. For this sensitivity model, it was assumed that those operator actions, whose cumulative F-V importance contributed to less than a 0.1% change in CDF, would not significantly impact the CDF and could be excluded from the reanalysis.

The sensitivity model followed a four-step process for both BVPS-1 and BVPS-2, except where differences were noted:

Evaluated all the "base case" PRA model operator actions, and ranked them by decreasing order of Fussell-Vesely (F-V) importance.

Evaluated the operator actions that are most important to the BVPS-1 and BVPS-2 PRA models. The only criteria for screening operator actions is that the screened out operator actions would have a cumulative impact on CDF of less than 0.1% of CDF. Thus, an iterative screening was performed on the list of operator actions, until the sum of the screened out operator actions was approximately equal to (but less than) 0.1% of CDF.

The remaining operator actions where then reevaluated using the success likelihood index methodology (SLIM) process with best-estimate timings based on MAAP results, to determine new baseline HEPs.

The new HEPs were entered in the BVPS-1 and BVPS-2 "base case" RISKMAN models and requantified to create the sensitivity models.

Furthermore, in order to gain an understanding of the increase in risk at BVPS-1 due to the increase in power alone, the steam generator tube rupture (SGTR) initiating event frequency needed to be equal in both this sensitivity model and in the BV1RAI model (the "base case" has the old SGTR frequency and the BV1RAI model has the new SGTR frequency). There were two approaches that could be used to accomplishing this. First, the post-EPU BV1RAI model may be modified to include the old SGTR initiating event frequency and then re-quantified. This could then be compared to the sensitivity model as described above. However, this approach requires that two PRA models be requantified. Therefore, the second approach was chosen. In the second option, the RSG initiating event frequency was used to requantify the sensitivity model described above. The change in steam generators would then become insignificant when evaluating a change in risk. This modified model became the BVPS-1 sensitivity model.

The new sensitivity model baseline CDF and LERF were then compared to the post-EPU CDF and LERF, for each unit, to determine a better comparison of the change in risk due to just the EPU.

Fussell-Vesely Rankings

The operator action importance rankings were extracted from the BV1REV3 and BV2REV3D models. The operator actions and their F-V rankings are shown in Table 3-4.

Table 3-4: Operator Action Importances

BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRBV3	Operators set up and start portable diesel driven fans to cool the emergency switchgear rooms upon failure of the normal switchgear ventilation fans and the emergency switchgear ventilation fans.	1.36E-01	OPROB1	Operators initiate bleed-and-feed operation by initiating safety injection, opening the PORVs, reopening the PORV block valves, and verifying High Head Safety Injection (HHSI) pump operation.	6.93E-02
OPRCD6	Operator depressurizes the RCS to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; HHSI has failed.	5.00E-02	OPROB2	Same as OB1 except that the actions take place after the operators fail to attempt to restore Main Feedwater (MFW).	3.45E-02
OPRCD7	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam, given HHSI failure and loss of emergency AC orange.	4.81E-02	OPRCD6	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side with HHSI failed (small LOCA).	2.51E-02
OPRWM1	Operator supplies borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations during an SGTR event	4.77E-02	OPRWM1	Operator supplies borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water during an SGTR event.	2.08E-02
OPRSL3	Operators locally gag the stuck-open steam relief valves during the SGTR event.	2.43E-02	OPRSL3	Operators locally gag the stuck-open steam relief valves during an SGTR event.	1.48E-02
OPROB2	Same as ZHEOB1 except that the actions take place after the operators fail to restore MFW and the dedicated aux feed pump.	1.57E-02	OPRIC1	Operator cross-ties station instrument air to containment instrument air.	1.04E-02
OPRCD3	Operator depressurizes the RCS following SGTR event and dumping of steam is done through the intact steam generator atmospheric steam dumps.	8.17E-03	OPRSL1	Operator identifies the ruptured steam generator, and isolates or verifies closed all flow paths to and from that steam generator, following an SGTR event.	5.41E-03
OPROC1	Operator trips RCP during loss of CCP.	8.06E-03	OPROS6	Operator starts AFW given failure of SSPS for sequences in which there is no safety injection; for example, turbine trip sequences.	4.23E-03
OPRSL1	Operator identifies the ruptured steam generator, and isolates or verifies closed all flow paths to and from that steam generator, following an SGTR event.	5.48E-03	OPROC1	Operator trips RCP during loss of CCP.	2.79E-03

Table 3-4: Operator Action Importances

BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRWA1	Operator manually starts and aligns auxiliary river water pumps to the required river water header given no LOSP.	5.12E-03	OPROS1	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment. Though there is no loss-of-coolant accident (LOCA) present, a valid safety injection condition has occurred; for example, steamline break.	2.67E-03
OPROP1	Operators protect RSS pumps by stopping them (QS failure) restarting when there is sufficient water in the sump.	3.51E-03	OPROT1	Operator pushes the manual reactor trip buttons after the Solid State Protection System (SSPS) fails to automatically actuate reactor trip in response to a plant trip condition	2.53E-03
OPROF6	Operator starts the dedicated AFW and manually controls the MFW bypass valve	2.81E-03	OPRWA4	Operator aligns the diesel-driven fire pump with offsite power available.	1.84E-03
OPRMU5	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following an interfacing systems LOCA.	2.81E-03	OPRPR1	Operator secures safety injection before PORVs are challenged.	1.72E-03
OPROS1	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a transient initiating event that leads to SI conditions. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	2.53E-03	OPRCD3	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig following a SGTR, and dumping of steam is done through the intact steam generator atmospheric steam dumps.	1.46E-03
OPROD1	Operator depressurizes RCS to RHS entry conditions using pressurizer spray/PORVs.	2.52E-03	OPROF2	Operator opens main feed bypass valves following a partial feedwater isolation event after a plant trip.	1.43E-03
OPROS6	Operator starts AFW given failure of SSPS for sequences in which there is no safety injection; e.g., turbine trip sequences.	2.39E-03	OPRMU2	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water following a small LOCA.	1.26E-03
OPRXT1	Operator failed to perform cross-tie during SBO.	1.56E-03	OPRWA1	Operator manually stops the EDG and racks the spare service water (SWS) pump onto the bus prior to restarting the EDG during a loss of offsite power.	1.25E-03

Table 3-4: Operator Action Importances					
BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			**BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)**		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPROC2	Operator trips RCP during loss of all seal cooling.	1.55E-03	OPROS2	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment. This event is following a small LOCA.	1.22E-03
OPRCD5	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam during a station blackout.	1.14E-03	OPROD1	Operator depressurizes RCS to Residual Heat Removal System (RHS) entry conditions after dumping steam via the atmospheric steam dumps to cool down the RCS, and to depressurize the RCS by using pressurizer spray/PORVs following a steam generator tube rupture (SGTR) event.	1.20E-03
OPRBV4	Operator starts the emergency switchgear ventilation exhaust fan VS-F-16B given the loss of normal switchgear ventilation and failure of the normally running emergency switchgear ventilation exhaust fan VS-F-16A, during a loss of offsite power.	1.03E-03	OPROC2	Operator trips RCP during loss of all seal cooling.	8.83E-04
OPROS2	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a small LOCA or steam line break. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	8.75E-04	OPRXT1	Operator failed to perform cross-tie during SBO.	8.11E-04
OPRHH1	Operator manually aligns power supply for the standby HHSI pump, starts and aligns the pump to provide the necessary flow after a small LOCA event.	6.97E-04	OPRWA2	Operator manually racks the spare service water (SWS) pump onto the emergency bus with offsite power available.	7.89E-04
OPRMU2	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following a small LOCA.	3.37E-04	OPRSM1	Operators monitor the operation of the RSS pumps, detect cavitation, and secure the pumps to prevent irreparable pump damage following a small LOCA accident and failure of the Quench Spray System.	6.69E-04
OPRWA2	Operator manually starts and aligns auxiliary river water pumps to the required river water header given LOSP.	3.22E-04	OPROA1	Operator starts charging/HHSI pumps and aligns an appropriate flow path for boron injection after an ATWS event.	5.20E-04

Table 3-4: Operator Action Importances					
BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPROB1	Operators initiate bleed and feed operation by initiating safety injection, opening the PORVs, opening the PORV block valves, and verifying HHSI pump operation.	1.98E-04	OPRCS1	Operator restores service water to the secondary component cooling system heat exchangers to maintain cooling to the station instrument air compressor, by opening appropriate motor-operated valves (MOVs) following a containment isolation (Phase A) signal.	4.53E-04
OPRCD4	Operator depressurizes the RCS following a SGTR, AC orange power has failed, and operators have to locally manipulate the steam generator atmospheric steam dumps to cooldown.	1.36E-04	OPRTB2	Operator reestablishes containment instrument air in the event of a CIA signal by resetting the CIA signal and realigning CCP flow to the Containment Instrument Air System.	4.00E-04
OPRWA5	Operator manually stops the EDG and aligns the diesel-driven fire pump during a loss of offsite power prior to restarting the emergency diesel generator.	1.34E-04	OPRIC2	Operator resets containment isolation Phase A (CIA) and restores containment instrument air.	3.95E-04
OPRWA8	Operator starts spare SW pump with offsite power available	1.25E-04	OPRWA6	Operator fails to align alternate supply of service water seal cooling.	3.63E-04
OPROA1	Operator starts charging/HHSI pumps and aligns an appropriate flow path for boron injection after an ATWS event.	1.13E-04	OPRCD7	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam, given HHSI failure and loss of emergency AC Orange.	3.28E-04
OPRSL2	Operators locally close the steam generator steam valves given that these valves cannot be closed remotely during an SGTR accident.	1.09E-04	OPRWA3	Operator starts standby service water (SWE) pump during loss of offsite power.	3.16E-04
OPRBV1	Operator opens the normal switchgear ventilation supply louvers VS-D-341, 342, and 343 to cool the emergency switchgear rooms upon failure of the normal switchgear ventilation chilled water cooling and the emergency switchgear ventilation.	9.63E-05	OPRSL2	Operators locally close the steam generator steam valves given that these valves cannot be closed remotely during an SGTR accident.	2.55E-04
OPROS3	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a medium LOCA. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	8.85E-05	OPROF1	Operators reestablish main feedwater following a safety injection signal by resetting the safety injection system, opening the feedwater isolation valves, and starting the startup feed pump or main feed pump.	2.45E-04
OPRWA7	Operator starts spare SW pump during a LOSP	8.29E-05	OPRHH1	Operator manually aligns power supply for the standby HHSI pump, and starts and aligns the pump to provide the necessary flow after a small LOCA event.	2.32E-04

Table 3-4: Operator Action Importances

BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRPR1	Operators close PORV block valve to isolate a stuck open PORV.	6.27E-05	OPROR1	Operators manually initiate recirculation mode of operation by starting the Recirculation Spray System (RSS) pumps, aligning power supplies to appropriate RSS equipment, resetting safety injection system, and verifying service water flow to RSS headers, following a small LOCA event.	1.82E-04
OPRIA1	Given LOSP, operators locally start the diesel air compressor.	5.16E-05	OPRHH2	Operators fail to properly monitor plant parameters and prematurely secure the safety injection system.	1.50E-04
OPROS4	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a large LOCA. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	3.72E-05	OPRPR2	Operator closes block valve.	1.22E-04
OPROF1	Operators align main feedwater or the dedicated auxiliary feed pump given the auxiliary feed was successful, but makeup to the PPDWST failed.	2.26E-05	OPROS3	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment; following a medium LOCA.	5.45E-05
OPRRI1	Operator manually inserts control rods following an ATWS event and Top Event OT is successful.	1.98E-05	OPRCD1	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side (small LOCA).	3.79E-05
OPROR2	Operators align outside recirculation spray trains A or B to the LHSI flow path for high pressure recirculation, given that both LHSI supply trains fail.	1.80E-05	OPRWA5	Operator manually stops the EDG and aligns the diesel-driven fire pump during a loss of offsite power prior to restarting the emergency diesel generator.	1.85E-05
OPRHH3	Operator switches to alternative AC/DC power.	1.62E-05	OPRMU3	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water following a medium LOCA	1.68E-05
OPRMU3	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following a medium LOCA.	5.20E-06	OPRRI1	Operator manually inserts control rods following an ATWS event and Top Event OT is successful.	1.60E-05

Table 3-4: Operator Action Importances

BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRCC1	Operators starts the manual standby CCR on loss of the operating and the automatic standby CCRs, to restore CCW flow to the RCP thermal barriers.	5.00E-06	OPRIA1	Operator aligns condensate polishing air compressor.	1.37E-05
OPRXT2	Operator failed to perform cross-tie during SBO and small LOCA or SGTR.	3.69E-06	OPRCD4	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; an SGTR event has occurred, AC Orange power has failed, and operators have to locally manipulate the steam generator atmospheric steam dumps to cool down. .	1.11E-05
OPRCD1	Operator depressurizes the RCS to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side (small LOCA).	3.51E-06	OPRMA1	Operator aligns gravity feed path from DWST to PPDWST.	6.92E-06
OPRWA4	Operator aligns the diesel-driven fire pump with offsite power available.	2.56E-06	OPRRR1	Operator initiates RHS operation by clearing caution tags, establishing cooling water to the RHS heat exchangers, aligning power supplies to RHS equipment, and energizing the system.	6.02E-06
OPRXT4	Operator fails to manually align SBO breakers.	2.11E-06	OPRHH3	Operator switches to alternative AC/DC power.	5.26E-06
OPRHC1	Operator opens alternate cold leg injection flow path (MOV-SI-836) during a small LOCA.	1.69E-06	OPROR2	Operators manually initiate recirculation mode of operation by starting the Recirculation Spray System (RSS) pumps, aligning power supplies to appropriate RSS equipment, resetting safety injection system, and verifying service water flow to RSS headers, following a large LOCA event.	2.94E-06
OPRIA2	Given no LOSP, operators start a compressor from the control room.	1.33E-06	OPRCC1	Operator starts the manual standby component cooling pump (CCP) on loss of the operating and the automatic standby CCPs, to restore component cooling water (CCW) flow to the RCP thermal barriers.	2.15E-06
OPRNA1	Operator transfers DC power to alternate supply.	1.06E-06	OPRCC3	Operator switches to alternative AC/DC power.	9.89E-07
OPROF2	Operators align main feedwater or the dedicated aux feedwater given aux feed fails and no CIA signal.	9.71E-07	OPRXT4	Operator fails to manually align SBO breakers.	2.50E-07

Table 3-4: Operator Action Importances					
BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			**BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)**		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRBV2	Operator starts the emergency switchgear ventilation exhaust fan VS-F-16B upon the loss of normal switchgear ventilation and failure of the normally running emergency switchgear ventilation exhaust fan VS-F-16A, given that offsite power is available and the plant has not tripped.	9.22E-07	OPRMA2	Operator aligns Service Water System emergency flow path to AFW pumps, given failure of normal makeup to PPDWST.	2.45E-07
OPROR1	Operators manually initiate recirculation mode of operation by starting the RSS pumps, aligning power supplies to appropriate RSS equipment, resetting safety injection system and verifying RW flow to RSS headers, following a small LOCA event.	6.49E-07	OPRXT2	Operator failed to perform cross-tie during SBO and small LOCA or SGTR.	2.32E-07
OPROF4	Operators align main feedwater or the dedicated aux feedwater given aux feed fails	6.33E-07	OPRCC2	Operator aligns the normally isolated CCP cooler to service water header A in the event that service water header B to the normally aligned cooler is lost.	2.30E-07
OPROF3	Operators align the dedicated aux feedwater given main feed and aux feed fails and no CIA signal.	3.40E-07	OPRMU1	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water following a transient-initiated small LOCA or SGTR.	0.00E+00
OPRCC3	Operator switches to alternative AC/DC power.	3.18E-07	OPROS4	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment; following a large LOCA.	0.00E+00
OPRIA4	Operators align the second dryer train locally.	4.40E-08	OPRRI2	Operator manually inserts control rods following an ATWS event and Top Event OT fails. For modeling convenience, no credit is conservatively assumed for this action.	0.00E+00
OPRCC2	Operator aligns the normally isolated CCR cooler to river water in the event that river water to the normally aligned cooler is lost.	1.23E-09	OPRRR2	Operator aligns alternate power supply to the RHS pump suction MOVs on loss of one emergency bus (AC Orange or Purple) following an SGTR event.	0.00E+00

Table 3-4: Operator Action Importances

BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRDF1	Operator opens manual valve FW-543 to supply alternate water supply to the dedicated auxiliary feed pump.	1.46E-10	OPRCD2	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; AC Orange power has failed and operators have to locally manipulate the steam generator atmospheric steam dumps to cool down.	N/A
OPRAF1	Operator opens manual valve MS-17 to supply steam to the turbine-drive from steam generator 1C.	5.57E-11	OPRPI1	Operator isolates the RCS relief paths due to stuck-open pressurizer PORVs after they were used to depressurize the RCS, by closing the PORV block valves associated with the stuck-open PORVs.	N/A
OPRMU1	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following a steam generator tube rupture event.	0.00E+00	OPRCI2	Operator isolates containment vents/drains by placing primary drains transfer and containment vacuum pump in pull-to-lock, stopping reactor sump pumps, and closing the pressurizer relief tank/PRI drains transfer tank vents.	N/A
OPRRI2	Operator manually inserts control rods following an ATWS event and Top Event OT fails. For modeling convenience, no credit is conservatively assumed for this action.	0.00E+00	OPRIA2	Operator aligns domestic water supply to station air compressors.	N/A
OPRRR1	Operator initiates RHS system operation by clearing caution tags, establishing cooling water to the RHS heat exchangers, aligning power supplies to RHS equipment, and energizing the system.	0.00E+00	OPRIA3	Operator aligns Service Water System water supply to station air compressors, given failure of primary and backup sources.	N/A
OPRPK1	Operator isolates stuck-open Pressurizer PORV used to depressurize, given ATWS	N/A	OPRCI1	Operator locally closes the RCP seal return isolation valves outside the containment given a loss of all AC power	N/A
OPROF5	Operators align main feedwater or the dedicated aux feedwater given auxiliary feed fails.	N/A	OPRCD5	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam during a station blackout (SBO).	N/A
OPRPI1	Operator isolates the RCS relief paths due to stuck-open pressurizer PORVs after they were used to depressurize the RCS, by closing the PORV block valves associated with the stuck-open PORVs.	N/A			
OPRCT1	Operator locally restores river water to a turbine plant component cooling heat exchanger by opening manual valves.	N/A			
OPRMA1	Operators supply alternate makeup to PPDWST (WT-TK-10).	N/A			

Table 3-4: Operator Action Importances

BVPS-1 Operator Action F-V Importance (based on BV1REV3 CDF)			BVPS-2 Operator Action F-V Importance (based on BV2REV3D CDF)		
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRCD2	Operator depressurizes the RCS to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; AC orange power has failed and operators have to locally manipulate the steam generator atmospheric steam dumps to cooldown.	N/A			
OPRIA3	Operators restore cooling to compressors by locally aligning filtered water given that CCT is unavailable and no LOSP.	N/A			
OPRMA2	Operators align river water to the auxiliary feedwater pumps suction.	N/A			
OPRHH2	Operators fail to properly monitor plant parameters and prematurely secure the safety injection system.	N/A			
OPRCI2	Operator isolates containment vents/drains by placing primary drains transfer and containment vacuum pump in pull-to-lock, stopping reactor sump pumps, and closing the PRT/PRI drains transfer tank vents.	N/A			
OPRCI1	Operator locally closes the RCP seal return isolation valves outside the containment given a loss of all AC power (station blackout).	N/A			
OPRIC2	Operators crosstie station instrument air to containment instrument air by locally opening manual valve IA-90.	N/A			

Screening Analysis

An iterative process was used to screen out the unimportant operator actions from the analysis. A base set of operator actions was chosen from Table 3-4 and the F-V importances were summed. The process began by starting at the bottom of the table (i.e., the least important operator action) for each unit and continually adding the next highest operator action and summing the F-V values. This action was repeated until the summed F-V value was at its highest value, without exceeding 0.1% of CDF. Those operator actions were then screened out from the analysis. The final screened out operator actions are shown in Table 3-5. The table also illustrates the summed F-V values and indicates that the total is less than 0.1% of CDF.

Table 3-5: Screening Analysis Results - Insignificant Operator Actions					
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRWA8	Operator starts spare SW pump with offsite power available	1.25E-04	OPRHH1	Operator manually aligns power supply for the standby HHSI pump, and starts and aligns the pump to provide the necessary flow after a small LOCA event.	2.32E-04
OPROA1	Operator starts charging/HHSI pumps and aligns an appropriate flow path for boron injection after an ATWS event.	1.13E-04	OPROR1	Operators manually initiate recirculation mode of operation by starting the Recirculation Spray System (RSS) pumps, aligning power supplies to appropriate RSS equipment, resetting safety injection system, and verifying service water flow to RSS headers, following a small LOCA event.	1.82E-04
OPRSL2	Operators locally close the steam generator steam valves given that these valves cannot be closed remotely during an SGTR accident.	1.09E-04	OPRHH2	Operators fail to properly monitor plant parameters and prematurely secure the safety injection system.	1.50E-04
OPRBV1	Operator opens the normal switchgear ventilation supply louvers VS-D-341, 342, and 343 to cool the emergency switchgear rooms upon failure of the normal switchgear ventilation chilled water cooling and the emergency switchgear ventilation.	9.63E-05	OPRPR2	Operator closes block valve.	1.22E-04
OPROS3	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a medium LOCA. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	8.85E-05	OPROS3	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment; following a medium LOCA.	5.45E-05
OPRWA7	Operator starts spare SW pump during a LOSP	8.29E-05	OPRCD1	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side (small LOCA).	3.79E-05
OPRPR1	Operators close PORV block valve to isolate a stuck open PORV.	6.27E-05	OPRWA5	Operator manually stops the EDG and aligns the diesel-driven fire pump during a loss of offsite power prior to restarting the emergency diesel generator.	1.85E-05
OPRIA1	Given LOSP, operators locally start the diesel air compressor.	5.16E-05	OPRMU3	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water following a medium LOCA	1.68E-05

Table 3-5: Screening Analysis Results - Insignificant Operator Actions					
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPROS4	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a large LOCA. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	3.72E-05	OPRRI1	Operator manually inserts control rods following an ATWS event and Top Event OT is successful.	1.60E-05
OPROF1	Operators align main feedwater or the dedicated aux feed pump given the aux feed was successful, but makeup to the PPDWST failed.	2.26E-05	OPRIA1	Operator aligns condensate polishing air compressor.	1.37E-05
OPRRI1	Operator manually inserts control rods following an ATWS event and Top Event OT is successful.	1.98E-05	OPRCD4	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; an SGTR event has occurred, AC Orange power has failed, and operators have to locally manipulate the steam generator atmospheric steam dumps to cool down. .	1.11E-05
OPROR2	Operators align outside recirculation spray trains A or B to the LHSI flow path for high pressure recirculation, given that both LHSI supply trains fail.	1.80E-05	OPRMA1	Operator aligns gravity feed path from DWST to PPDWST.	6.92E-06
OPRHH3	Operator switches to alternative AC/DC power.	1.62E-05	OPRRR1	Operator initiates RHS operation by clearing caution tags, establishing cooling water to the RHS heat exchangers, aligning power supplies to RHS equipment, and energizing the system.	6.02E-06
OPRMU3	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following a medium LOCA.	5.20E-06	OPRHH3	Operator switches to alternative AC/DC power.	5.26E-06
OPRCC1	Operators starts the manual standby CCR on loss of the operating and the automatic standby CCRs, to restore CCW flow to the RCP thermal barriers.	5.00E-06	OPROR2	Operators manually initiate recirculation mode of operation by starting the Recirculation Spray System (RSS) pumps, aligning power supplies to appropriate RSS equipment, resetting safety injection system, and verifying service water flow to RSS headers, following a large LOCA event.	2.94E-06
OPRXT2	Operator failed to perform cross-tie during SBO and small LOCA or SGTR.	3.69E-06	OPRCC1	Operator starts the manual standby component cooling pump (CCP) on loss of the operating and the automatic standby CCPs, to restore component cooling water (CCW) flow to the RCP thermal barriers.	2.15E-06

Table 3-5: Screening Analysis Results - Insignificant Operator Actions					
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPRCD1	Operator depressurizes the RCS to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side (small LOCA).	3.51E-06	OPRCC3	Operator switches to alternative AC/DC power.	9.89E-07
OPRWA4	Operator aligns the diesel-driven fire pump with offsite power available.	2.56E-06	OPRXT4	Operator fails to manually align SBO breakers.	2.50E-07
OPRXT4	Operator fails to manually align SBO breakers.	2.11E-06	OPRMA2	Operator aligns Service Water System emergency flow path to AFW pumps, given failure of normal makeup to PPDWST.	2.45E-07
OPRHC1	Operator opens alternate cold leg injection flow path (MOV-SI-836) during a small LOCA.	1.69E-06	OPRXT2	Operator failed to perform cross-tie during SBO and small LOCA or SGTR.	2.32E-07
OPRIA2	Given no LOSP, operators start a compressor from the control room.	1.33E-06	OPRCC2	Operator aligns the normally isolated CCP cooler to service water header A in the event that service water header B to the normally aligned cooler is lost.	2.30E-07
OPRNA1	Operator transfers DC power to alternate supply.	1.06E-06	OPRMU1	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water following a transient-initiated small LOCA or SGTR.	0.00E+00
OPROF2	Operators align main feedwater or the dedicated aux feedwater given aux feed fails and no CIA signal.	9.71E-07	OPROS4	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment; following a large LOCA.	0.00E+00
OPRBV2	Operator starts the emergency switchgear ventilation exhaust fan VS-F-16B upon the loss of normal switchgear ventilation and failure of the normally running emergency switchgear ventilation exhaust fan VS-F-16A, given that offsite power is available and the plant has not tripped.	9.22E-07	OPRRI2	Operator manually inserts control rods following an ATWS event and Top Event OT fails. For modeling convenience, no credit is conservatively assumed for this action.	0.00E+00
OPROR1	Operators manually initiate recirculation mode of operation by starting the RSS pumps, aligning power supplies to appropriate RSS equipment, resetting safety injection system and verifying RW flow to RSS headers, following a small LOCA event.	6.49E-07	OPRRR2	Operator aligns alternate power supply to the RHS pump suction MOVs on loss of one emergency bus (AC Orange or Purple) following an SGTR event.	0.00E+00

Table 3-5: Screening Analysis Results - Insignificant Operator Actions					
BVPS-1 Operator Action	**BVPS-1 Description**	**BVPS-1 F-V Importance**	**BVPS-2 Operator Action**	**BVPS-2 Description**	**BVPS-2 F-V Importance**
OPROF4	Operators align main feedwater or the dedicated auxiliary feedwater given aux feed fails	6.33E-07	OPRCD2	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; AC Orange power has failed and operators have to locally manipulate the steam generator atmospheric steam dumps to cool down.	N/A
OPROF3	Operators align the dedicated aux feedwater given main feed and auxiliary feed fails and no CIA signal.	3.40E-07	OPRPI1	Operator isolates the RCS relief paths due to stuck-open pressurizer PORVs after they were used to depressurize the RCS, by closing the PORV block valves associated with the stuck-open PORVs.	N/A
OPRCC3	Operator switches to alternative AC/DC power.	3.18E-07	OPRCI2	Operator isolates containment vents/drains by placing primary drains transfer and containment vacuum pump in pull-to-lock, stopping reactor sump pumps, and closing the pressurizer relief tank/PRI drains transfer tank vents.	N/A
OPRIA4	Operators align the second dryer train locally.	4.40E-08	OPRIA2	Operator aligns domestic water supply to station air compressors.	N/A
OPRCC2	Operator aligns the normally isolated CCR cooler to river water in the event that river water to the normally aligned cooler is lost.	1.23E-09	OPRIA3	Operator aligns Service Water System water supply to station air compressors, given failure of primary and backup sources.	N/A
OPRDF1	Operator opens manual valve FW-543 to supply alternate water supply to the dedicated auxiliary feed pump.	1.46E-10	OPRCI1	Operator locally closes the RCP seal return isolation valves outside the containment given a loss of all AC power	N/A
OPRAF1	Operator opens manual valve MS-17 to supply steam to the turbine-drive from steam generator 1C.	5.57E-11	OPRCD5	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam during a station blackout (SBO).	N/A
OPRMU1	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following a steam generator tube rupture event.	0.00E+00			
OPRRI2	Operator manually inserts control rods following an ATWS event and Top Event OT fails. For modeling convenience, no credit is conservatively assumed for this action.	0.00E+00			
OPRRR1	Operator initiates RHS system operation by clearing caution tags, establishing cooling water to the RHS heat exchangers, aligning power supplies to RHS equipment, and energizing the system.	0.00E+00			

Table 3-5: Screening Analysis Results - Insignificant Operator Actions

BVPS-1 Operator Action	BVPS-1 Description	BVPS-1 F-V Importance	BVPS-2 Operator Action	BVPS-2 Description	BVPS-2 F-V Importance
OPRPK1	Operator isolates stuck-open Pressurizer PORV used to depressurize, given ATWS	N/A			
OPROF5	Operators align main feedwater or the dedicated auxiliary feedwater given aux feed fails.	N/A			
OPRPI1	Operator isolates the RCS relief paths due to stuck-open pressurizer PORVs after they were used to depressurize the RCS, by closing the PORV block valves associated with the stuck-open PORVs.	N/A			
OPRCT1	Operator locally restores river water to a turbine plant component cooling heat exchanger by opening manual valves.	N/A			
OPRMA1	Operators supply alternate makeup to PPDWST (WT-TK-10).	N/A			
OPRCD2	Operator depressurizes the RCS to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; AC orange power has failed and operators have to locally manipulate the steam generator atmospheric steam dumps to cooldown.	N/A			
OPRIA3	Operators restore cooling to compressors by locally aligning filtered water given that CCT is unavailable and no LOSP.	N/A			
OPRMA2	Operators align river water to the auxiliary feedwater pumps suction.	N/A			
OPRHH2	Operators fail to properly monitor plant parameters and prematurely secure the safety injection system.	N/A			
OPRCI2	Operator isolates containment vents/drains by placing primary drains transfer and containment vacuum pump in pull-to-lock, stopping reactor sump pumps, and closing the PRT/PRI drains transfer tank vents.	N/A			
OPRCI1	Operator locally closes the RCP seal return isolation valves outside the containment given a loss of all AC power (station blackout).	N/A			
OPRIC2	Operators crosstie station instrument air to containment instrument air by locally opening manual valve IA-90.	N/A			
F-V Total		8.74E-04	F-V Total		8.79E-04
% CDF		0.087%	% CDF		0.088%

Human Reliability Analysis

The operator actions that were not previously screened out were reanalyzed using the SLIM HRA methodology. All changes in the HRA were made to the sensitivity models. Specifically, the time performance shaping factor (PSF) was altered to reflect the best-estimate timings from the MAAP analyses. The results of the sensitivity model were then compared to the post-EPU RAI models, to gain a better understanding of the change in risk due to just the EPU.

In the case of BVPS-1, there were no MAAP analyses to reference for the "base case" conditions. In this instance, engineering judgment was used to determine the change in PSF for the given operator actions. The following criteria were used to determine the change in PSF for BVPS-1:

At a minimum, the sensitivity study PSF should be less than or equal to the PSF for the RAI model. The basis for this is that it is expected that the increase in power level would result in a decrease in operator action time available. To reflect this, the sensitivity study PSF would be lowered. This is a recognized conservatism in the analysis.

Also, it is assumed that the sensitivity study PSF should be less than or equal to the PSF resulting from the simplified hand calculations. The simplified hand calculations are assumed to have some conservatism in the operator action time available. It is assumed that the best-estimate MAAP runs would result in more time for the operator to perform his task (as was the case for BVPS-2).

The engineering judgment used the change in times from the BVPS-2 analysis, when applicable. The relative change in PSF for the BVPS-2 models could be applied to the BVPS-1 models, as a guideline for how the PSF may be impacted at BVPS-1.

The BVPS-1 operator actions were reviewed in detail to determine the appropriate Time PSF. The BVPS-1 HRA notebook contains detailed information regarding the requirements of the operator for the given accident scenario. In many instances, the operator action was simple enough to warrant no change in the PSF.

Results of the HRA for the BVPS-1 sensitivity model are provided in Table 3-6. This table shows the times produced by the simplified hand calculations for the "base case", and the times produced by MAAP for the post-EPU. Furthermore, the sensitivity model PSFs and HEPs are shown, with a comparison to the BV1REV3 "base case" operator action PSFs and HEPs, and the post-EPU BV1RAI PSFs and HEPs. The details of the HRA for the operator actions reanalyzed for the BVPS-1 sensitivity model are provided in the attached SLIM worksheets (included as Attachment 1), which provide the rankings, weightings, and HEP mean values for each human interaction within the group.

During the BV2REV3D PRA update, MAAP analyses were performed for the BVPS-2 model. However, due to conservative modeling assumptions, the simplified operator action time available calculations were maintained in the model. However, those MAAP analyses were used in this sensitivity study to gain an understanding of the best-estimate operator action time available. Using the MAAP analyses, the sensitivity model PSFs were modified to produce a best-estimate HRA. In the instances that no MAAP analyses exist for a given operator action, the same criteria listed above for BVPS-1 were applied.

Results of the HRA for the BVPS-2 sensitivity model are provided in Table 3-7. This table shows the times produced by the simplified hand calculations for the "base case", and the times produced by MAAP for the post-EPU. Furthermore, the sensitivity model PSFs and HEPs are shown, with a comparison to the BV2REV3D "base case" operator action PSFs and HEPs, and the post-EPU BV2RAI PSFs and HEPs. The details of the HRA for the operator actions reanalyzed for the BVPS-2 sensitivity model are provided in the attached SLIM worksheets (included as Attachment 2), which provide the rankings, weightings, and HEP mean values for each human interaction within the group.

Table 3-6: Beaver Valley Unit 1 Human Reliability Analysis Summary

Basic Event	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV1REV3 Time PSF	BV1REV3 Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability
OPRBV3	Operators set up and start portable diesel driven fans to cool the emergency switchgear rooms upon failure of the normal switchgear ventilation fans and the emergency switchgear ventilation fans.	0.5 hours	(1)	N/A	8	7.12E-02	8	7.11E-02	8	7.11E-02
OPRBV4	Operator starts the emergency switchgear ventilation exhaust fan VS-F-16B given the loss of normal switchgear ventilation and failure of the normally running emergency switchgear ventilation exhaust fan VS-F-16A, during a loss of offsite power.	0.5 hours	(1)	N/A	5	6.97E-03	5	6.97E-03	5	6.97E-03
OPRCD3	Operator depressurizes the RCS following SGTR event and dumping of steam is done through the intact steam generator atmospheric steam dumps.	11 hours	(1)	>24 hours	5	5.12E-03	1	3.92E-03	2	4.19E-03
OPRCD4	Operator depressurizes the RCS following a SGTR, AC orange power has failed, and operators have to locally manipulate the steam generator atmospheric steam dumps to cooldown.	3.1 hours	(1)	N/A	5	8.30E-02	1	5.10E-02	1	5.10E-02
OPRCD5	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam during a station blackout.	4 hours	(1)	2.61 hours	2	1.94E-02	1	1.76E-02	5	2.56E-02
OPRCD6	Operator depressurizes the RCS to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side; HHSI has failed.	0.83 hours	(1)	1 hour	3	4.99E-02	2	4.40E-02	2	4.40E-02

Table 3-6: Beaver Valley Unit 1 Human Reliability Analysis Summary										
Basic Event	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV1REV3 Time PSF	BV1REV3 Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability
OPRCD7	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam, given HHSI failure and loss of emergency AC orange.	0.83 hours	(1)	1 hour	5	1.35E-01	3	1.05E-01	4	1.20E-01
OPRHH1	Operator manually aligns power supply for the standby HHSI pump, starts and aligns the pump to provide the necessary flow after a small LOCA event.	0.67 hours	(1)	0.94 hours	4	3.88E-03	0	2.52E-03	2	3.13E-03
OPRMU2	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following a small LOCA.	0.79 hours	(1)	2.58 hours	3	1.01E-02	2	9.19E-03	3	1.01E-02
OPRMU5	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations following an interfacing systems LOCA.	7 hours	(1)	N/A	1	6.25E-03	0	5.85E-03	1	6.25E-03
OPROB1	Operators initiate bleed and feed operation by initiating safety injection, opening the PORVs, opening the PORV block valves, and verifying HHSI pump operation.	0.95 (57 minutes)	(1)	42 minutes(2)	1	1.22E-03	1(3)	1.22E-03	2(3)	1.37E-03
OPROB2	Same as ZHEOB1 except that the actions take place after the operators fail to restore MFW and the dedicated auxiliary feed pump.	0.95 (57 minutes)	(1)	29 minutes(2)	1	1.39E-02	2(3)	1.53E-02	3(3)	1.68E-02
OPROC1	Operator trips RCP during loss of CCP. (Based on BVPS-2 ZHESE1)	5 minutes	(1)	N/A	7	4.79E-03	7	4.79E-03	7	4.79E-03
OPROC2	Operator trips RCP during loss of all seal cooling. (Based on BVPS-2 ZHESE1)	5 minutes	(1)	N/A	7	4.79E-03	7	4.79E-03	7	4.79E-03
OPROD1	Operator depressurizes RCS to RHS entry conditions using pressurizer spray/PORVs.	8 hours	(1)	>24 hours	1	1.59E-03	0	1.42E-03	0	1.42E-03

Table 3-6: Beaver Valley Unit 1 Human Reliability Analysis Summary

Basic Event	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV1REV3 Time PSF	BV1REV3 Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability
OPROF6	Operator starts the dedicated AFW and manually controls the MFW bypass valve	N/A	(1)	N/A	N/A	1.94E-02 (assigned)	N/A	1.94E-02 (assigned)	N/A	1.94E-02 (assigned)
OPROP1	Operators protect RSS pumps by stopping them (QS failure) restarting when there is sufficient water in the sump. (Based on BVPS-2 ZHESM1)	8.5 minutes	(1)	N/A	7	5.36E-02	7	5.36E-02	7	5.36E-02
OPROS1	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a transient initiating event that leads to SI conditions. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	1.03 hours	(1)	0.72 hours	3	6.42E-03	2	5.86E-03	5	7.68E-03
OPROS2	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of SSPS due to actuation relay failure given a small LOCA or steam line break. On failure of manual safety injection actuation, the operator manually aligns the safety equipment.	0.67 hours	(1)	0.94 hours	5	9.19E-03	2	7.01E-03	3	7.68E-03
OPROS6	Operator starts AFW given failure of SSPS for sequences in which there is no safety injection; e.g., turbine trip sequences.	1.03 hours	(1)	N/A	0	8.15E-04	0	8.11E-04	3	1.12E-03
OPRSL1	Operator identifies the ruptured steam generator, and isolates or verifies closed all flow paths to and from that steam generator, following an SGTR event.	0.64 hours	(1)	1.6 hours	3	3.37E-03	2	2.01E-03	3	3.38E-03
OPRSL3	Operators locally gag the stuck-open steam relief valves during the SGTR event.	9.5 hours	(1)	>24 hours	1	1.86E-01	0	1.65E-01	1	1.84E-01

Table 3-6: Beaver Valley Unit 1 Human Reliability Analysis Summary

Basic Event	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV1REV3 Time PSF	BV1REV3 Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability
OPRWA1	Operator manually starts and aligns auxiliary river water pumps to the required river water header given no LOSP.	1 hour	(1)	1 hour	5	7.81E-03	4	7.01E-03	5	7.80E-03
OPRWA2	Operator manually starts and aligns auxiliary river water pumps to the required river water header given LOSP.	13 minutes	(1)	1 hour	7	2.73E-02	6	1.98E-02	7	2.73E-02
OPRWA5	Operator manually stops the EDG and aligns the diesel-driven fire pump during a loss of offsite power prior to restarting the emergency diesel generator. (Based on BVPS-2 ZHEWA5)	30 minutes	(1)	1 hour	6	2.14E-01	6	2.14E-01	6	2.14E-01
OPRWA8	Operator starts spare SW pump with offsite power available. (Based on BVPS-2 ZHEWA2)	1 hour	(1)	1 hour	5	5.21E-03	5	5.21E-03	5	5.21E-03
OPRWM1	Operator supplies borated makeup water to the RWST initially from the spent fuel pool, and, in the long term, from blending operations during an SGTR event	21 hours	(1)	>24 hours	1	8.41E-03	0	7.68E-03	0	7.68E-03
OPRXT1	Operator failed to perform cross-tie during SBO.	3.1 hours	(1)	N/A	5	1.28E-02	4	1.06E-02	5	1.28E-02

(1) No MAAP4 analyses are available, engineering judgment is used to determine the change in PSF.

(2) Post-EPU MAAP analyses performed in response to RAI 2.d indicate that the OPROB1 timing is 42 minutes and that the OPROB2 timing is 29 minutes, as opposed to 65 minutes reported in Reference 1.

(3) The OPROB1 and OPROB2 PSFs were modified to reflect the post-EPU MAAP analysis performed in response to RAI 2.d.

Table 3-7: Beaver Valley Unit 2 Human Reliability Analysis Summary										
Operator Action	**Description**	**Simplified Calculation Pre-EPU Timing**	**MAAP4 Pre-EPU Timing**	**MAAP EPU Timing**	**BV2REV3D Time PSF**	**BV2REV3D Mean Probability**	**Sensitivity Model Time PSF**	**Sensitivity Model Mean Probability**	**EPU RAI Time PSF**	**EPU RAI Mean Probability**
OPRCD3	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig following a SGTR, and dumping of steam is done through the intact steam generator atmospheric steam dumps.	14 hours	N/A(1)	>24 hours	1	1.45E-03	0	1.21E-03	0	1.21E-03
OPRCD6	Operator depressurizes the Reactor Coolant System (RCS) to 400 psig by dumping steam through the steam generator atmospheric steam dumps to depressurize and cool down the secondary side with HHSI failed (small LOCA).	0.83 hours	1 hour	1 hour	3	7.65E-02	3	7.65E-02	3	7.65E-02
OPRCD7	Operator depressurizes the RCS to 400 psig by locally manipulating the steam generator atmospheric steam dumps to relief steam, given HHSI failure and loss of emergency AC Orange.	0.83 hours)	1 hour	1 hour	4	1.65E-01	4	1.65E-01	4	1.65E-01
OPRCS1	Operator restores service water to the secondary component cooling system heat exchangers to maintain cooling to the station instrument air compressor, by opening appropriate motor-operated valves (MOVs) following a containment isolation (Phase A) signal.	0.84 hours	1.3 hours	N/A	6	2.07E-02	6	2.06E-02	7	2.37E-02
OPRIC1	Operator cross-ties station instrument air to containment instrument air. (Based on ZHETB2)	1 hour	30 minutes	N/A	1	7.94E-04	1	7.92E-04	1	7.92E-04
OPRIC2	Operator resets containment isolation Phase A (CIA) and restores containment instrument air.	1 hour	30 minutes	N/A	1	1.10E-02	1	1.12E-02	1	1.12E-02
OPRMU2	Operators provide borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water following a small LOCA.	1.01 hours	1.55 hours	2.58 hours	3	5.97E-03	1	4.97E-03	2	5.45E-03

Table 3-7: Beaver Valley Unit 2 Human Reliability Analysis Summary

Operator Action	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV2REV3D Time PSF	BV2REV3D Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability
OPROA1	Operator starts charging/HHSI pumps and aligns an appropriate flow path for boron injection after an ATWS event.	10 minutes	N/A(1)	N/A	2	3.83E-03	2	3.83E-03	2	3.84E-03
OPROB1	Operators initiate bleed-and-feed operation by initiating safety injection, opening the PORVs, reopening the PORV block valves, and verifying High Head Safety Injection (HHSI) pump operation.	58 minutes	78 minutes	42 minutes(2)	7	4.34E-03	1(3)	1.87E-03	2(3)	2.15E-03
OPROB2	Same as OB1 except that the actions take place after the operators fail to attempt to restore Main Feedwater (MFW).	58 minutes	78 minutes	29 minutes(2)	7	3.79E-02	2(3)	2.49E-02	3(3)	2.71E-02
OPROC1	Operator trips RCP during loss of CCP. (Based on ZHESE1)	5 minutes	N/A(1)	N/A	7	4.79E-03	7	4.79E-03	7	4.79E-03
OPROC2	Operator trips RCP during loss of all seal cooling. (Based on ZHESE1)	5 minutes	N/A(1)	N/A	7	4.79E-03	7	4.79E-03	7	4.79E-03
OPROD1	Operator depressurizes RCS to Residual Heat Removal System (RHS) entry conditions after dumping steam via the atmospheric steam dumps to cool down the RCS, and to depressurize the RCS by using pressurizer spray/PORVs following a steam generator tube rupture (SGTR) event.	14 hours	N/A(1)	>24 hours	1	1.19E-03	0	1.04E-03	0	1.04E-03
OPROF1	Operators reestablish main feedwater following a safety injection signal by resetting the safety injection system, opening the feedwater isolation valves, and starting the startup feed pump or main feed pump.	0.84 hours	1.3 hours	0.72 hours	2	1.19E-03	1	1.05E-03	4	1.59E-03
OPROF2	Operator opens main feed bypass valves following a partial feedwater isolation event after a plant trip.	0.84 hours	1.3 hours	0.72 hours	1	3.36E-04	0	2.93E-04	3	4.46E-04

Table 3-7: Beaver Valley Unit 2 Human Reliability Analysis Summary

Operator Action	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV2REV3D Time PSF	BV2REV3D Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability
OPROS1	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment. Though there is no loss-of-coolant accident (LOCA) present, a valid safety injection condition has occurred; for example, steamline break.	0.85 hours	1.3 hours	0.72 hours	3	1.05E-02	2	9.15E-03	5	1.33E-02
OPROS2	Operator manually actuates safety injection and verifies operation of certain safety equipment on loss of both trains of SSPS due to actuation relay failure. On failure of manual safety injection actuation, the operator manually aligns the safety equipment. This event is following a small LOCA.	0.67 hours	0.89 hours	0.94 hours	4	1.71E-02	2	1.33E-02	2	1.33E-02
OPROS6	Operator starts AFW given failure of SSPS for sequences in which there is no safety injection; for example, turbine trip sequences.	1.3 hours	1.3 hours	N/A	N/A(2)	1.00E-03 (assigned)	N/A	1.00E-03 (assigned)	N/A	1.00E-03 (assigned)
OPROT1	Operator pushes the manual reactor trip buttons after the Solid State Protection System (SSPS) fails to automatically actuate reactor trip in response to a plant trip condition	1 minute(3)	N/A(1)	N/A	5	1.35E-03	5	1.37E-03	5	1.37E-03
OPRPR1	Operator secures safety injection before PORVs are challenged.	27 minutes	27 minutes	33 minutes	N/A	1.0 (assigned)	N/A	1.0 (assigned)	N/A	1.0 (assigned)
OPRSL1	Operator identifies the ruptured steam generator, and isolates or verifies closed all flow paths to and from that steam generator, following an SGTR event.	0.93 hours	1.8 hours	1.6 hours	7	5.26E-03	4	3.02E-03	5	3.63E-03

Table 3-7: Beaver Valley Unit 2 Human Reliability Analysis Summary										
Operator Action	**Description**	**Simplified Calculation Pre-EPU Timing**	**MAAP4 Pre-EPU Timing**	**MAAP EPU Timing**	**BV2REV3D Time PSF**	**BV2REV3D Mean Probability**	**Sensitivity Model Time PSF**	**Sensitivity Model Mean Probability**	**EPU RAI Time PSF**	**EPU RAI Mean Probability**
OPRSL2	Operators locally close the steam generator steam valves given that these valves cannot be closed remotely during an SGTR accident.	11.2 hours	23.1 hours	>24 hours	2	4.26E-03	0	3.28E-03	0	3.28E-03
OPRSL3	Operators locally gag the stuck-open steam relief valves during an SGTR event.	11.2 hours	23.1 hours	>24 hours	N/A	1.0 (assigned)	N/A	1.0 (assigned)	N/A	1.0 (assigned)
OPRSM1	Operators monitor the operation of the RSS pumps, detect cavitation, and secure the pumps to prevent irreparable pump damage following a small LOCA accident and failure of the Quench Spray System.	5 minutes	5 minutes	N/A	7	5.36E-02	7	5.36E-02	7	5.36E-02
OPRTB2	Operator reestablishes containment instrument air in the event of a CIA signal by resetting the CIA signal and realigning CCP flow to the Containment Instrument Air System.	1 hour	30 minutes	30 minutes	1	1.10E-02	1	1.12E-02	1	1.12E-02
OPRWA1	Operator manually stops the EDG and racks the spare service water (SWS) pump onto the bus prior to restarting the EDG during a loss of offsite power.	1 hour	30 minutes	30 minutes	6	7.93E-02	6	7.93E-02	6	7.93E-02
OPRWA2	Operator manually racks the spare service water (SWS) pump onto the emergency bus with offsite power available.	1 hour	30 minutes	30 minutes	5	5.21E-03	5	5.21E-03	5	5.20E-03
OPRWA3	Operator starts standby service water (SWE) pump during loss of offsite power.	1 hour	30 minutes	30 minutes	6	7.93E-02	6	7.93E-02	6	7.93E-02
OPRWA4	Operator aligns the diesel-driven fire pump with offsite power available.	1 hour	30 minutes	30 minutes	5	1.89E-02	5	1.89E-02	5	1.89E-02
OPRWA6	Operator fails to align alternate supply of service water seal cooling.	1 hour	30 minutes	30 minutes	2	2.47E-02	2	2.47E-02	2	2.48E-02
OPRWM1	Operator supplies borated makeup water to the RWST initially from the spent fuel pool, and in the long term, with makeup from service water during an SGTR event.	38 hours	N/A(1)	>24 hours	0	5.97E-03	0	5.97E-03	0	5.97E-03
OPRXT1	Operator failed to perform cross-tie during SBO.	3.1 hours	3.1 hours	N/A	5	3.57E-02	4	2.89E-02	5	3.57E-02

Table 3-7: Beaver Valley Unit 2 Human Reliability Analysis Summary										
Operator Action	Description	Simplified Calculation Pre-EPU Timing	MAAP4 Pre-EPU Timing	MAAP EPU Timing	BV2REV3D Time PSF	BV2REV3D Mean Probability	Sensitivity Model Time PSF	Sensitivity Model Mean Probability	EPU RAI Time PSF	EPU RAI Mean Probability

1. No MAAP4 analyses are available, engineering judgment is used to determine the change in PSF.
2. Post-EPU MAAP analyses performed in response to RAI 2.d indicate that the OPROB1 timing is 42 minutes and that the OPROB2 timing is 29 minutes, as opposed to 65 minutes reported in Reference 1.
3. In response to RAI 2.d, a review of operator actions OPROB1 and OPROB2 determined that the PSF estimates were inconsistent with BVPS-1 values. These operator actions are expected to need only 5 minutes to complete; thus, the 58 minutes available to complete the action is more than sufficient. Therefore, the sensitivity model has reevaluated the operator actions and determined more realistic Time PSFs. Consequently, the RAI model was also modified to account for this new information.

Results

The results of the quantification are summarized in Table 3-8 and Table 3-9, for BVPS-1 and BVPS-2, respectively.

Using the new BVPS-1 sensitivity model CDF and LERF and comparing those values to the analyses provided in the RAI responses, the BVPS-1 post-EPU PRA is indicating an increase in risk. The total CDF is increasing 2.88E-07 per year for the post-EPU conditions. This increase in CDF is considered small (less than 10^{-6}) and is acceptable per the guidance provided in Regulatory Guide 1.174 (Reference 3). The total LERF is increasing 5.83E-08 per year for the post-EPU. Again, this increase in LERF is considered small (less than 10^{-7}) and is acceptable per the guidance provided in Regulatory Guide 1.174.

Similarly, using the BVPS-2 sensitivity study CDF and LERF and comparing those values to the analyses provided in the RAI responses, the post-EPU BVPS-2 PRA is indicating an increase in risk. The total CDF is increasing 3.41E-07 per year for the post-EPU. This increase in CDF is considered small (less than 10^{-6}) and is acceptable per the guidance provided in Regulatory Guide 1.174. The total LERF is increasing 4.61E-08 per year for the post-EPU. Again, this increase in LERF is considered small (less than 10^{-7}) and is acceptable per the guidance provided in Regulatory Guide 1.174.

While the change in CDF at BVPS-1 is smaller than the change in CDF at BVPS-2, there is a larger change in LERF. In both models, LERF is dominated by SGTR and interfacing systems LOCA (ISLOCA) events. However, at BVPS-1, the PRA model assumes that ISLOCA events can be mitigated, given that a HHSI pump can provide continued RCS inventory makeup via the RWST. Since there was an increase in the HEP for makeup to the RWST following an ISLOCA (operator action OPRMU5) from the sensitivity model to the post-EPU RAI model (from 5.85E-03 to 6.25E-03), there was a resultant increase in the ISLOCA conditional large early release probability (LERP) which caused an increase in the LERF.

At BVPS-2, the PRA models did not credit any mitigating actions to reduce the ISLOCA since the initiating event frequency was almost 2 orders of magnitude lower than at BVPS-1 (1.07E-05 at BVPS-1 vs. 2.80E-07 at BVPS-2), due to system arrangements. As a result, the ISLOCA conditional LERP remains constant at 1.0 for both the pre and post-EPU cases, so the resultant increase is zero and the ISLOCA LERF contribution remains the same as the initiating event frequency for both cases.

Additionally, at BVPS-1 operators were credited for closing a stuck-open steam generator safety valve (operator action OPRSL3) during SGTR events, while no credit was given for this action at BVPS-2. Since there was an increase in this HEP from the BVPS-1 sensitivity model to the post-EPU RAI model (from 1.65E-01 to 1.84E-01), there was a resultant increase to the SGTR conditional LERP, which also caused an increase in the LERF contribution. At BVPS-2, this operator action was assigned a HEP of 1.0 for both the sensitivity and post-EPU RAI models, so the resultant increase on the SGTR conditional LERP was not as significant as BVPS-1. That is to say, the BVPS-2 SGTR conditional LERP is only impacted by changes to operator action OPRSL1; whereas, at BVPS-1 it is impacted by both changes to OPRSL1 and OPRSL3.

A summary of these conditional LERP values for the pre-EPU sensitivity models and post-EPU RAI models is presented in Table 3-10. In the table, the SGTR initiating events are broken down by steam generator A, B, or C (designated SGTRA, SGTRB, and SGTRC, respectively). The ISLOCA is designated by initiating event VSX for V-sequence. As seen in the table, the impact to LERF at BVPS-1 is more sensitive to the post-EPU HEPs than at BVPS-2, represented by the larger increase in the SGTR and ISLOCA conditional LERP values.

Table 3-8: BVPS-1 Results				
BVPS-1 Risk Measures	**BV1REV3**	**Sensitivity Model [2]**	**EPU RAI [1] [2]**	**Change in Risk (RAI - Sensitivity)**
CDF TOTAL (/year)	2.37E-05	2.26E-05	2.29E-05	2.88E-07
CDF Internal (/year)	7.45E-06	6.25E-06	6.54E-06	2.86E-07
CDF External (/year)	1.63E-05	1.63E-05	1.63E-05	2.00E-09
CDF Fires (/year)	4.60E-06	4.66E-06	4.66E-06	2.23E-10
LERF TOTAL (/year)	1.03E-06	4.37E-07	4.95E-07	5.83E-08

1. Reference 2 analysis modified to include new OPROB1 and OPROB2 HEPs.
2. Analysis includes RSG SGTR Initiating Event Frequency.

Table 3-9: BVPS-2 Results				
BVPS-2 Risk Measures	**BV2REV3D**	**Sensitivity Model**	**EPU RAI [1]**	**Change in Risk (RAI - Sensitivity)**
CDF TOTAL (/year)	3.49E-05	3.30E-05	3.33E-05	3.41E-07
CDF Internal (/year)	2.00E-05	1.86E-05	1.88E-05	2.78E-07
CDF External (/year)	1.48E-05	1.44E-05	1.45E-05	6.30E-08
CDF Fires (/year)	5.29E-06	4.89E-06	4.95E-06	6.40E-08
LERF TOTAL (/year)	1.12E-06	1.03E-06	1.07E-06	4.61E-08

1. Reference 2 analysis modified to include new OPROB1 and OPROB2 HEPs.

Table 3-10: Initiating Event Conditional LERP				
	IE Frequency	LERF	Conditional LERP	% LERF
BVPS-1				
Sensitivity				
SGTRA	6.96E-04	1.20E-07	1.72E-04	27.4%
SGTRB	6.96E-04	1.20E-07	1.72E-04	27.4%
SGTRC	6.96E-04	1.20E-07	1.72E-04	27.4%
VSX	1.07E-05	7.63E-08	7.13E-03	17.5%
Others		1.78E-09		0.4%
		4.37E-07		**100.0%**
EPU RAI				
SGTRA	6.96E-04	1.38E-07	1.98E-04	27.8%
SGTRB	6.96E-04	1.38E-07	1.98E-04	27.8%
SGTRC	6.96E-04	1.38E-07	1.98E-04	27.8%
VSX	1.07E-05	8.06E-08	7.53E-03	16.3%
Others		1.83E-09		0.4%
		4.95E-07		**100.0%**
BVPS-2				
Sensitivity				
VSX	2.80E-07	2.80E-07	1.00E+00	27.2%
SGTRA	1.61E-03	2.48E-07	1.54E-04	24.1%
SGTRB	1.61E-03	2.48E-07	1.54E-04	24.1%
SGTRC	1.61E-03	2.48E-07	1.54E-04	24.1%
Others		4.79E-09		0.5%
		1.03E-06		**100.0%**
EPU RAI				
VSX	2.80E-07	2.80E-07	1.00E+00	26.0%
SGTRA	1.61E-03	2.63E-07	1.63E-04	24.5%
SGTRB	1.61E-03	2.64E-07	1.64E-04	24.5%
SGTRC	1.61E-03	2.63E-07	1.63E-04	24.5%
Others		4.85E-09		0.5%
		1.07E-06		**100.0%**

References

1. FENOC Letter L-05-104, "Beaver Valley Power Station Unit Nos. 1 and 2, BV-1 Docket No. 50-334, License No. DPR-66, BV-2 Docket No. 50-412, License No. NPF-73, Probabilistic Safety Review for License Amendment Request Nos. 302 and 173", June 14, 2005

2. FENOC Letter L-05-140, "Beaver Valley Power Station, Unit Nos. 1 and 2, BV-1 Docket No. 50-334, License No. DPR-66, BV-2 Docket No. 50-214, License No. NPF-73, Response to a Request for Additional Information (RAI dated August 2, 2005 in Support of License Amendment Request Nos. 302 and 173, Extended Power Uprate", September 6, 2005.

3. U.S. NRC Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis", Revision 1, November 2002.

Enclosure 2 Attachment 1 of L-05-192

BVPS-1 Sensitivity Study HRA Worksheets

BEAVER VALLEY UNIT 1 - GROUP 1 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.13	0.13	0.13	0.31	0.13	0.06	0.13	1.00		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.99E-01	-0.0006
ZHEOR1	5	5	5	3	5	2	5	4.188	2.01E-03	-2.6970
ZHECD3	8	2	9	2	8	1	6	4.813	3.92E-03	-2.4071
ZHEMU5	8	4	6	5	6	0	5	5.188	5.85E-03	-2.2331
MIN HER	0	0	0	0	0	0	0	0	2.29E-05	-4.6394

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
DC ZHERF1 (1)	5	5	5	3	5	2	5	4.188	2.00E-03	-2.6990
MIN HER	0	0	0	0	0	0	0	0	2.30E-05	-4.6383

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV1 (ZHEOR1)

Regression Output:

Constant	-4.63941
Std Err of Y Est	0.002418
R Squared	0.999999
No. of Observations	3
Degrees of Freedom	1
X Coefficient(s)	0.4638592
Std Err of Coef.	0.0003404

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEOR1	0	0	0	5	0	0	0	5	7.5	9.49E-04
ZHECD3	5	5	5	10	5	5	5	40	7.5	1.85E-03
ZHEMU5	5	5	5	10	5	0	5	35	7.5	2.76E-03
NORMALIZED PSF WEIGHTS	0.13	0.13	0.13	0.31	0.13	0.06	0.13	1		

Figure 1: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 1

BEAVER VALLEY UNIT 1 - GROUP 2 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.08	0.00	0.33	0.33	0.08	0.08	0.08	1.00		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.99E-01	-0.0003
ZHEMU1	8	5	8	5	2	1	4	5.583	8.40E-03	-2.0757
ZHEMU2	8	6	8	5	2	2	4	5.667	9.19E-03	-2.0365
ZHEOR2	7	7	6	3	5	2	5	4.583	2.85E-03	-2.5456
ZHEWM1	8	5	8	5	2	0	4	5.5	7.68E-03	-2.1149
ZHEOS1	7	1	7	5	3	2	3	5.25	5.86E-03	-2.2323
ZHEOS2	7	1	7	5	3	2	5	5.417	7.01E-03	-2.1540
MIN HER	0	0	0	0	0	0	0	0	2.00E-05	-4.6993

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
PLANT-X OFBPO1 (1)	7	1	7	5	3	3	3	5.333	6.40E-03	-2.1938
MIN HER	0	0	0	0	0	0	0	0	2.00E-05	-4.6990

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV1 (ZHEOS1)

Regression Output:

Constant		-4.69927
Std Err of Y Est		0.000789
R Squared		1
No. of Observations		3
Degrees of Freedom		1
X Coefficient(s)	0.4696927	
Std Err of Coef.	0.0001115	

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEMU1	0	0	5	5	0	0	0	10	7.5	3.97E-03
ZHEMU2	0	0	5	5	0	0	0	10	7.5	4.34E-03
ZHEOR2	0	0	5	5	0	0	0	10	7.5	1.34E-03
ZHEWM1	0	0	5	5	0	0	0	10	7.5	3.62E-03
ZHEOS1	5	0	10	10	5	5	5	40	7.5	2.77E-03
ZHEOS2	5	0	10	10	5	5	5	40	7.5	3.31E-03
NORMALIZED PSF WEIGHTS	0.08	0.00	0.33	0.33	0.08	0.08	0.08	1		

Figure 2: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 2

BEAVER VALLEY UNIT 1 - GROUP 3 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.12	0.12	0.10	0.10	0.07	0.24	0.24	1.00		
OPERATOR ACTIONS				PSF RANKINGS				FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.36E-01	-0.0285
ZHECD2	2	6	8	5	7	2	4	4.241	2.58E-03	-2.5886
ZHEHM1	2	1	2	2	4	6	6	3.948	1.91E-03	-2.7190
ZHERE6	1	2	8	9	9	7	7	6.121	1.77E-02	-1.7531
ZHEFL1	7	7	9	9	6	6	8	7.345	6.18E-02	-1.2089
ZHEFL2	7	7	9	9	6	5	8	7.103	4.83E-02	-1.3162
ZHEFL3	7	7	9	9	6	5	8	7.103	4.83E-02	-1.3162
ZHEIC3	6	9	8	2	9	6	8	6.845	3.70E-02	-1.4312
MIN HER	0	0	0	0	0	0	0	0	3.36E-05	-4.4743

CALIBRATION TASKS				PSF RANKINGS				FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
STP HEOS01	4	3	6	10	10	6	3	5.362	1.80E-02	-1.7447
FERMI RE7	6	7	6	8	6	5	8	6.569	1.32E-02	-1.8794
MIN HER	0	0	0	0	0	0	0	0	3.00E-05	-4.5229

Regression Output:

Constant	-4.47426
Std Err of Y Est	0.338135
R Squared	0.978095
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.444575
Std Err of Coef.	0.0470447

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
				PSF WEIGHTS						
ZHECD2	5	5	5	5	5	10	10	45	7.5	1.22E-03
ZHEHM1	5	5	5	5	5	10	10	45	7.5	9.02E-04
ZHERE6	5	5	5	5	5	10	10	45	5	1.09E-02
ZHEFL1	5	5	5	5	0	10	10	40	5	3.83E-02
ZHEFL2	5	5	5	5	0	10	10	40	5	2.99E-02
ZHEFL3	5	5	5	5	0	10	10	40	5	2.99E-02
ZHEIC3	5	5	0	0	5	10	10	35	5	2.30E-02
NORMALIZED PSF WEIGHTS	0.12	0.12	0.10	0.10	0.07	0.24	0.24	1		

Figure 3: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 3

BEAVER VALLEY UNIT 1 - GROUP 4 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.13	0.11	0.13	0.11	0.13	0.11	0.30	1.00		
OPERATOR ACTIONS			PSF RANKINGS					FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.15E-01	-0.0387
ZHEHC1	2	1	2	2	4	0	5	2.83	2.58E-04	-3.5885
ZHEPR1	2	2	2	2	3	0	6	3.106	3.53E-04	-3.4516
ZHECD4	9	2	9	8	8	1	10	7.468	5.10E-02	-1.2922
ZHEMU3	8	6	8	5	8	5	6	6.553	1.80E-02	-1.7451
ZHEMU4	8	6	8	5	8	7	8	7.362	4.52E-02	-1.3449
ZHEOB1	2	6	3	2	4	1	7	4.191	1.22E-03	-2.9144
ZHEOA1	2	0	2	0	3	2	7	3.191	3.90E-04	-3.4095
ZHEOT1	0	10	1	2	3	1	6	3.681	6.80E-04	-3.1672
MIN HER	0	0	0	0	0	0	0	0	1.02E-05	-4.9895

CALIBRATION TASKS			PSF RANKINGS					FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
STP HERC4	2	8	3	5	6	1	6	4.681	9.82E-04	-3.0079
FERMI HECT3	4	6	3	3	3	3	3	3.447	1.15E-03	-2.9393
MIN HER	0	0	0	0	0	0	0	0	9.20E-06	-5.0362

Regression Output:

Constant		-4.98954
Std Err of Y Est		0.342488
R Squared		0.961802
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	0.4950857	
Std Err of Coef.	0.0476608	

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
			PSF WEIGHTS							
ZHEHC1	0	0	0	0	0	0	5	5	10	9.68E-05
ZHEPR1	0	0	0	0	0	0	5	5	10	1.33E-04
ZHECD4	5	5	5	5	5	5	10	40	5	3.16E-02
ZHEMU3	5	5	5	5	5	5	10	40	5	1.11E-02
ZHEMU4	5	5	5	5	5	5	10	40	5	2.80E-02
ZHEOB1	5	5	5	5	5	5	10	40	7.5	5.75E-04
ZHEOA1	5	5	5	5	5	0	10	35	10	1.46E-04
ZHEOT1	5	0	5	0	5	5	10	30	10	2.55E-04
NORMALIZED PSF WEIGHTS	0.13	0.11	0.13	0.11	0.13	0.11	0.30	1		

Figure 4: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 4

BEAVER VALLEY UNIT 1 - GROUP 5 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.15	0.15	0.15	0.15	0.15	0.11	0.14	1.00		
OPERATOR ACTIONS			PSF RANKINGS					FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.97E-01	-0.0012
ZHECC1	2	6	6	7	2	2	5	4.37	4.21E-03	-2.3761
ZHECC2	2	6	7	7	2	4	6	4.883	6.92E-03	-2.1597
ZHECI2	1	2	4	1	3	3	3	2.403	6.22E-04	-3.2061
ZHEHH1	1	7	5	5	2	0	6	3.644	2.52E-03	-2.5980
ZHEHH2	2	2	3	1	3	3	4	2.545	7.15E-04	-3.1459
ZHEMA1	2	5	4	2	6	0	2	3.123	1.25E-03	-2.9021
ZHEMA2	2	3	1	2	8	0	5	3.104	1.23E-03	-2.9103
ZHEOD1	2	3	5	2	5	0	5	3.253	1.42E-03	-2.8473
ZHEPI1	0	0	1	5	3	2	5	2.279	5.52E-04	-3.2582
ZHEPK1	0	1	1	5	3	2	5	2.429	6.38E-04	-3.1952
ZHERE5	1	2	8	9	9	2	5	5.266	1.00E-02	-1.9981
ZHERR1	2	2	5	5	4	2	2	3.195	1.34E-03	-2.8719
ZHESE1	2	5	2	3	4	4	4	3.403	1.64E-03	-2.7843
ZHESL2	3	2	8	5	4	2	8	4.649	5.52E-03	-2.2584
ZHESL3	7	10	9	9	10	0	10	8.149	1.65E-01	-0.7819
ZHEWA1	5	5	5	4	7	4	4	4.896	7.01E-03	-2.1543
ZHEAF1	8	6	2	5	5	0	5	4.597	5.24E-03	-2.2803
ZHEDF1	6	1	5	2	6	1	6	3.955	2.81E-03	-2.5515
ZHEIA1	6	6	6	4	4	1	5	4.708	5.84E-03	-2.2337
ZHEIA2	4	6	5	4	4	1	5	4.26	3.78E-03	-2.4227
ZHEIA4	7	7	5	3	4	1	3	4.422	4.42E-03	-2.3542
ZHEOS6	2	4	2	5	3	0	2	2.675	8.11E-04	-3.0911
ZHEPNA	8	9	8	9	8	7	9	8.331	1.97E-01	-0.7052
MIN HER	0	0	0	0	0	0	0	0	6.03E-05	-4.2196

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION	
OPERATOR ACTIONS		PSF WEIGHTS							RANGE FACTOR	MEDIAN
ZHECC1	5	5	5	5	5	5	5	35	7.5	1.99E-03
ZHECC2	5	5	5	5	5	5	5	35	7.5	3.27E-03
ZHECI2	5	5	5	5	5	5	5	35	10	2.34E-04
ZHEHH1	5	5	5	5	5	5	5	35	7.5	1.19E-03
ZHEHH2	5	5	5	5	5	5	5	35	10	2.68E-04
ZHEMA1	5	5	5	5	5	5	5	35	7.5	5.92E-04
ZHEMA2	5	5	5	5	5	5	5	35	7.5	5.81E-04
ZHEOD1	5	5	5	5	5	5	5	35	7.5	6.71E-04
ZHEPI1	5	5	5	5	5	5	5	35	10	2.07E-04
ZHEPK1	5	5	5	5	5	5	5	35	10	2.40E-04
ZHERE5	5	5	5	5	5	5	5	35	5	6.22E-03
ZHERR1	5	5	5	5	5	5	5	35	7.5	6.34E-04
ZHESE1	5	5	5	5	5	5	5	35	7.5	7.76E-04
ZHESL2	5	5	5	5	5	5	5	35	7.5	2.61E-03
ZHESL3	5	5	5	5	5	5	5	35	3	1.32E-01
ZHEWA1	5	5	5	5	5	5	5	35	7.5	3.31E-03
ZHEAF1	5	5	5	5	5	0	5	30	7.5	2.48E-03
ZHEDF1	5	5	5	5	5	0	5	30	7.5	1.33E-03
ZHEIA1	5	5	5	5	5	0	5	30	7.5	2.76E-03
ZHEIA2	5	5	5	5	5	0	5	30	7.5	1.78E-03
ZHEIA4	5	5	5	5	5	0	5	30	7.5	2.09E-03
ZHEOS6	5	5	5	5	5	0	0	25	10	3.04E-04
ZHEPNA	5	5	5	5	5	5	5	35	3	1.58E-01
NORMLAIZED PSF WEIGHTS	0.15	0.15	0.15	0.15	0.15	0.11	0.14	1		

Figure 5: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 5

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
STP HEOD03	6	5	6	6	8	6	9	6.578	4.38E-02	-1.3585
STP HEOSL1	3	4	5	3	3	4	6	3.987	2.13E-03	-2.6716
STP HEOC01	3	3	6	4	4	2	4	3.779	2.31E-03	-2.6364
MIN HER	0	0	0	0	0	0	0	0	6.90E-05	-4.1612

Regression Output:

Constant		-4.21965
Std Err of Y Est		0.098056
R Squared		0.997057
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	0.4218417	
Std Err of Coef.	0.013232	

Figure 5 (Cont.): BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 5

BEAVER VALLEY UNIT 1 - GROUP 6 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS		SUM		
Norm. PSF Weights	0.00	0.50	0.00	0.00	0.00	0.50	0.00		1.00		
OPERATOR ACTIONS	PSF RANKINGS								FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10		10	9.98E-01	-0.0007
ZHESL1	6	6	6	5	3	2	5		4	2.01E-03	-2.6961
ZHETT1	4	5	2	3	3	7	5		6	1.59E-02	-1.7976
MIN HER	0	0	0	0	0	0	0		0	3.21E-05	-4.4930
CALIBRATION TASKS	PSF RANKINGS								FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10		10	1.00E+00	0.0000
STP HEOSL1	3	4	5	3	3	4	6		4	2.13E-03	-2.6716
DC ZHEOX1 (1)	6	6	6	5	3	3	5		4.5	3.20E-03	-2.4949
MIN HER	0	0	0	0	0	0	0		0	3.20E-05	-4.4949

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV1 (ZHESL1)

Regression Output:

Constant		-4.49301
Std Err of Y Est		0.023969
R Squared		0.999688
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	0.4492291	
Std Err of Coef.	0.0033667	

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRUBITION: RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHESL1	0	5	0	0	0	5	0	10	7.5	9.51E-04
ZHETT1	0	5	0	0	0	5	0	10	5	9.87E-03
NORMALIZED PSF WEIGHTS	0.00	0.50	0.00	0.00	0.00	0.50	0.00	1		

Figure 6: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 6

BEAVER VALLEY UNIT 1 - GROUP 7 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.10	0.25	0.10	0.10	0.10	0.10	0.25	1.00		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.99E-01	-0.0005
ZHECI1	2	5	3	3	5	2	3	3.5	2.23E-03	-2.6512
ZHECD5	1	6	8	5	7	1	8	5.7	1.76E-02	-1.7541
ZHEOB2	2	9	3	2	4	2	8	5.55	1.53E-02	-1.8152
MIN HER	0	0	0	0	0	0	0	0	8.35E-05	-4.0785

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
STP HEOB02	4	3	6	4	7	2	8	5.05	8.80E-03	-2.0555
OPRA-8 (1)	2	9	3	2	4	1	8	5.45	1.00E-02	-2.0000
DC ZHEOB1	5	7	7	6	6	4	8	6.55	5.49E-02	-1.2604
MIN HER	0	0	0	0	0	0	0	0	9.00E-05	-4.0458

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV1 (ZHEOB2)

Regression Output:

Constant		-4.07855
Std Err of Y Est		0.122121
R Squared		0.99483
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	0.4078012	
Std Err of Coef.	0.0169732	

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHECI1	0	5	0	0	0	0	5	10	7.5	1.05E-03
ZHECD5	5	10	5	5	5	5	10	45	5	1.09E-02
ZHEOB2	5	10	5	5	5	5	10	45	5	9.48E-03
NORMALIZED PSF WEIGHTS	0.10	0.25	0.10	0.10	0.10	0.10	0.25	1		

Figure 7: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 7

BEAVER VALLEY UNIT 1 - GROUP 8 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
Norm. PSF Weights	0.13	0.13	0.10	0.10	0.11	0.31	0.11	1.00

OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.96E-01	-0.0018
ZHEFL4	3	3	3	5	7	4	3	3.971	2.34E-03	-2.6305
ZHETT2	4	3	2	3	3	5	3	3.657	1.71E-03	-2.7675
ZHEWA2	6	6	6	7	7	6	5	6.1	1.98E-02	-1.7023
ZHEBV2	3	3	3	4	7	2	2	3.129	1.00E-03	-2.9980
ZHEBV3	5	7	7	9	9	8	6	7.371	7.11E-02	-1.1479
ZHEBV4	5	6	3	4	7	5	5	5.057	6.97E-03	-2.1571
ZHECD1	2	5	8	3	5	2	4	3.657	1.71E-03	-2.7675
ZHECT1	2	6	6	7	2	6	5	5.014	6.67E-03	-2.1758
ZHEIA3	6	6	6	4	4	10	5	6.714	3.68E-02	-1.4345
ZHERI1	1	0	1	0	0	5	7	2.6	5.91E-04	-3.2285
ZHEIC2	2	6	4	3	4	5	4	4.214	2.99E-03	-2.5246
ZHEIC1	6	7	6	2	6	2	3	4.129	2.74E-03	-2.5620
MIN HER	0	0	0	0	0	0	0	0	4.34E-05	-4.3622

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
FERMI HERS1	2	7	2	3	2	4	6	3.829	1.75E-03	-2.7570
STP HEOS01	4	3	6	10	10	6	3	5.871	1.80E-02	-1.7447
MIN HER	0	0	0	0	0	0	0	0	4.60E-05	-4.3372

Regression Output:

Constant	-4.36218
Std Err of Y Est	0.058576
R Squared	0.999309
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.43604
Std Err of Coef.	0.0081103

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEFL4	0	0	0	0	0	5	0	5	7.5	1.11E-03
ZHETT2	0	0	0	0	0	5	0	5	7.5	8.07E-04
ZHEWA2	0	0	0	0	0	10	0	10	5	1.23E-02
ZHEBV2	5	5	5	5	5	10	5	40	7.5	4.74E-04
ZHEBV3	5	5	5	0	5	10	5	35	5	4.41E-02
ZHEBV4	5	5	5	5	5	10	5	40	7.5	3.29E-03
ZHECD1	5	5	5	5	5	10	5	40	7.5	8.07E-04
ZHECT1	5	5	5	5	5	10	5	40	7.5	3.15E-03
ZHEIA3	5	5	5	5	5	10	5	40	5	2.28E-02
ZHERI1	5	5	5	5	5	10	5	40	10	2.22E-04
ZHEIC2	5	5	0	5	5	10	5	35	7.5	1.41E-03
ZHEIC1	5	5	0	0	0	10	0	20	7.5	1.29E-03
NORMALIZED PSF WEIGHTS	0.13	0.13	0.10	0.10	0.11	0.31	0.11	1		

Figure 8: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 8

BEAVER VALLEY UNIT 1 - GROUP 9 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PROCEDIENG	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS		SUM		
Norm. PSF Weights	0.00	0.17	0.17	0.17	0.17	0.17	0.17		1.00		
OPERATOR ACTIONS			PSF RANKINGS						FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10		10	9.98E-01	-0.0008
ZHECD6	2	9	5	3	7	2	9		5.833	4.40E-02	-1.3564
ZHECD7	2	9	8	5	8	3	9		7	1.05E-01	-0.9768
MIN HER	0	0	0	0	0	0	0		0	5.57E-04	-3.2542
CALIBRATION TASKS			PSF RANKINGS						FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10		10	1.00E+00	0.0000
STP HECD03	6	5	6	6	8	6	9		6.667	4.38E-02	-1.3585
EPRI SH1 (1)	2	9	5	3	7	3	9		6	1.00E-01	-1.0000
MIN HER	0	0	0	0	0	0	0		0	5.20E-04	-3.2840

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV1 (ZHECD6)

Regression Output:

Constant	-3.2542
Std Err of Y Est	0.288842
R Squared	0.970575
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.3253357
Std Err of Coef.	0.0400552

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PROCEDIENG	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
		PSF WEIGHTS								
ZHECD6	0	5	5	5	5	5	5	30	5	2.73E-02
ZHECD7	0	5	5	5	5	5	5	30	3	8.44E-02
NORMALIZED PSF WEIGHTS	0.00	0.17	0.17	0.17	0.17	0.17	0.17	1		

Figure 9: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 9

BEAVER VALLEY UNIT 1 - GROUP 10 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
Norm. PSF Weights	0.11	0.00	0.22	0.22	0.11	0.22	0.11	1.00

OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.99E-01	-0.0006
ZHEOS3	7	1	7	5	3	3	6	5.111	1.57E-02	-1.8037
ZHEOS4	7	1	7	5	3	8	8	6.444	4.88E-02	-1.3120
MIN HER	0	0	0	0	0	0	0	0	2.05E-04	-3.6888

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
STP HEOR07	5	4	7	4	6	5	6	5.444	2.08E-02	-1.6819
MIN HER	0	0	0	0	0	0	0	0	2.05E-04	-3.6882

Regression Output:	
Constant	-3.68877
Std Err of Y Est	0.001415
R Squared	1
No. of Observations	3
Degrees of Freedom	1
X Coefficient(s)	0.3688144
Std Err of Coef.	0.0001999

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEOS3	5	0	10	10	5	10	5	45	5	9.74E-03
ZHEOS4	5	0	10	10	5	10	5	45	5	3.02E-02
NORMALIZED PSF WEIGHTS	0.11	0.00	0.22	0.22	0.11	0.22	0.11	1		

Figure 10: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 10

BEAVER VALLEY UNIT 1 - GROUP 11 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIMES	STRESS	SUM		
Norm. PSF Weights	0.13	0.13	0.26	0.11	0.13	0.13	0.13	1.00		
OPERATOR ACTIONS			PSF RANKINGS					**FLI**	**HER**	**LOG(HER)**
MAX HER	10	10	10	10	10	10	10	10	9.99E-01	-0.0006
ZHEOF1	5	5	5	5	4	1	2	3.979	1.58E-04	-3.8005
ZHEOF2	5	5	5	5	4	1	3	4.106	1.91E-04	-3.7199
ZHEOF3	5	6	5	5	6	1	5	4.745	4.82E-04	-3.3171
ZHEOF4	5	6	5	5	4	1	4	4.362	2.76E-04	-3.5588
ZHEOF5	5	6	5	5	6	1	5	4.745	4.82E-04	-3.3171
ZHEXT1	8	9	10	1	4	4	8	6.872	1.06E-02	-1.9744
MIN HER	0	0	0	0	0	0	0	0	4.88E-07	-6.3114
CALIBRATION TASKS			PSF RANKINGS					**FLI**	**HER**	**LOG(HER)**
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
SEABROOK ON	0	0	1	0	2	0	0	0.511	1.00E-06	-6.0000
MIN HER	0	0	0	0	0	0	0	0	5.00E-07	-6.3010

Regression Output:

Constant		-6.31136
Std Err of Y Est		0.015023
R Squared		0.999991
No. of Observations		3
Degrees of Freedom		1
X Coefficient(s)	0.631081	
Std Err of Coef.	0.0018862	

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIMES	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION: RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEOF1	5	5	10	5	5	5	5	40	10	5.94E-05
ZHEOF2	5	5	10	5	5	5	5	40	10	7.15E-05
ZHEOF3	5	5	10	5	5	5	5	40	10	1.81E-04
ZHEOF4	5	5	10	5	5	5	5	40	10	1.04E-04
ZHEOF5	5	5	10	5	5	5	5	40	10	1.81E-04
ZHEXT1	5	5	10	0	5	5	5	35	5	6.57E-03
NORMALIZED PSF WEIGHTS	0.13	0.13	0.26	0.11	0.13	0.13	0.13	1		

Figure 11: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 11

BEAVER VALLEY UNIT 1 - GROUP 12 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.22	0.11	0.22	0.11	0.11	0.11	0.11	1.00		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.32E-01	-0.0306
ZHECR3	9	8	8	5	2	5	6	6.667	3.37E-02	-1.4725
ZHECR4	9	5	9	4	4	5	8	6.889	4.20E-02	-1.3764
ZHECSF	9	5	9	4	4	5	8	6.889	4.20E-02	-1.3764
MIN HER	0	0	0	0	0	0	0	0	4.40E-05	-4.3563
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
BIG ROCK BR5	6	5	6	5	6	5	6	5.667	1.40E-02	-1.8539
BIG ROCK L2C	4	4	4	4	4	5	4	4.111	1.00E-03	-3.0000
SEQUOYAH CT1	2	3	5	0	4	2	2	2.778	1.80E-03	-2.7447
MIN HER	0	0	0	0	0	0	0	0	3.75E-05	-4.4260

Regression Output:		
Constant		-4.35625
Std Err of Y Est		0.343813
R Squared		0.966676
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	0.432562	
Std Err of Coef.	0.0463682	

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION	
OPERATOR ACTIONS	PSF WEIGHTS								RANGE FACTOR	MEDIAN
ZHECR3	10	5	10	5	5	5	5	45	5	2.09E-02
ZHECR4	10	5	10	5	5	5	5	45	5	2.60E-02
ZHECSF	10	5	10	5	5	5	5	45	5	2.60E-02
NORMALIZED PSF WEIGHTS	0.22	0.11	0.22	0.11	0.11	0.11	0.11	1		

Figure 12: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 12

BEAVER VALLEY UNIT 1 - GROUP 13 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.08	0.08	0.08	0.08	0.27	0.27	0.14	1.00		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.69E-01	-0.0135
ZHEPAE	8	6	8	5	8	7	8	7.324	5.11E-02	-1.2912
MIN HER	0	0	0	0	0	0	0	0	1.63E-05	-4.7887
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
SEQUOYAH FLPH3CR	4	1	3	0	4	4	5	3.486	5.80E-04	-3.2366
SEQUOYAH FLAB3C	6	8	0	8	4	4	6	4.757	4.40E-03	-2.3565
SEQUOYAH FLAB1R	4	1	3	0	4	2	5	2.946	3.60E-04	-3.4202
SEQUOYAH FLPH1R	4	1	3	0	4	4	5	3.486	5.80E-04	-3.2366
MIN HER	0	0	0	0	0	0	0	0	2.00E-05	-4.6990

Regression Output:

Constant		-4.78865
Std Err of Y Est		0.123436
R Squared		0.995087
No. of Observations		6
Degrees of Freedom		4
X Coefficient(s)	0.477516	
Std Err of Coef.	0.0167764	

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION: RANGE FACTOR	MEDIAN
PSF WEIGHTS										
ZHECR3	3	3	3	3	10	10	5	37	5	3.17E-02
NORMALIZED PSF WEIGHTS	0.08	0.08	0.08	0.08	0.27	0.27	0.14	1		

Figure 13: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 13

BEAVER VALLEY UNIT 1 - GROUP 14 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.13	0.13	0.13	0.13	0.26	0.08	0.13	1.00		
OPERATOR ACTIONS			PSF RANKINGS					FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.59E-01	-0.0182
ZHENSF	8	6	8	5	4	4	5	5.579	6.58E-03	-2.1819
MIN HER	0	0	0	0	0	0	0	0	1.22E-05	-4.9123
CALIBRATION TASKS			PSF RANKINGS					FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
PLG CAL 3.1	6	5	6	5	6	5	6	5.658	1.40E-02	-1.8539
PLG CAL 3.2	4	4	4	4	4	5	4	4.079	1.00E-03	-3.0000
PLG CAL 3.3	7	6	7	6	7	6	6	6.526	2.50E-02	-1.6021
PLG CAL 3.4	9	8	9	9	9	9	9	8.868	1.50E-01	-0.8239
MIN HER	0	0	0	0	0	0	0	0	1.00E-05	-5.0000

Regression Output:

Constant		-4.91226
Std Err of Y Est		0.209632
R Squared		0.988696
No. of Observations		6
Degrees of Freedom		4
X Coefficient(s)	0.489409	
Std Err of Coef.	0.0261659	

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
	PSF WEIGHTS							
ZHENSF	5	5	5	5	10	3	5	38
NORMALIZED PSF WEIGHTS	0.13	0.13	0.13	0.13	0.26	0.08	0.13	1

INPUT TO RISKMAN FOR HER DISTRIBUTION

RANGE FACTOR	MEDIAN
7.5	3.11E-03

Figure 14: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 14

BEAVER VALLEY UNIT 1 - GROUP 15 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.11	0.11	0.22	0.11	0.11	0.22	0.11	1.00		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.95E-01	-0.0022
ZHEXT2	8	9	10	1	4	9	9	7.667	1.28E-01	-0.8911
MIN HER	0	0	0	0	0	0	0	0	1.54E-04	-3.8117
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
DC ZHEOS1	2	2	1	5	5	3	4	2.889	1.50E-03	-2.8239
STP HEOR07	7	5	5	4	5	6	6	5.444	2.08E-02	-1.6819
MIN HER	0	0	0	0	0	0	0	0	1.75E-04	-3.7570

Regression Output:

Constant	-3.81172
Std Err of Y Est	0.096985
R Squared	0.997603
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.380950
Std Err of Coef.	0.0132029

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
	PSF WEIGHTS							
ZHEXT2	5	5	10	5	5	10	5	45
NORMALIZED PSF WEIGHTS	0.11	0.11	0.22	0.11	0.11	0.22	0.11	1

INPUT TO RISKMAN FOR HER DISTRIBUTION

RANGE FACTOR	MEDIAN
3	1.03E-01

Figure 15: BVPS-1 Pre-EPU Sensitivity Model SLIM Worksheet Group 15

Enclosure 2 Attachment 2 of L-05-192

BVPS-2 Sensitivity Study HRA Worksheets

BEAVER VALLEY UNIT 2 - GROUP 1 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm PSF Weights	0.116	0.233	0.116	0.116	0.116	0.233	0.07	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	8	8	8	8	8	8	8	8	4.80E-01	-3.19E-01
ZHEPR1	2	8	4	2	3	9	6	5.65	3.44E-02	-1.46E+00
ZHESM1	5	8	4	5	5	7	5	6.05	5.36E-02	-1.27E+00
ZHEWA1	7	8	7	5	5	6	5	6.40	7.93E-02	-1.10E+00
ZHEWA3	7	8	7	5	5	6	5	6.40	7.93E-02	-1.10E+00
ZHEWA5	7	8	7	7	10	6	6	7.28	2.14E-01	-6.70E-01
MIN HER	2	2	2	2	2	2	2	2	5.72E-04	-3.24E+00
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	8	8	8	8	8	8	8	8	1.00E+00	0.00E+00
FERM OE1	4	6	4	4	5	4	4	4.5814	4.31E-03	-2.37E+00
STP HEOR05	7	7	8	5	8	8	6	7.1628	1.24E-01	-9.07E-01
MIN HER	2	2	2	2	2	2	2	2	1.00E-03	-3.00E+00

Regression Output:

Constant	-4.2167171
Std Err of Y Est	0.411007816
R Squared	0.939482569
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.487245984
Std Err of Coef.	0.087443826

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEPR1	5	10	5	5	5	10	5	45	5	2.13E-02
ZHESM1	5	10	5	5	5	10	5	45	5	3.32E-02
ZHEWA1	5	10	5	5	5	10	0	40	5	4.91E-02
ZHEWA3	5	10	5	5	5	10	0	40	5	4.91E-02
ZHEWA5	5	10	5	5	5	10	5	45	3	1.71E-01
NORMALIZED PSF WEIGHTS	0.116	0.233	0.116	0.116	0.116	0.233	0.07	1		

Figure 16: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 1

BEAVER VALLEY UNIT 2 - GROUP 2 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	FLI	HER	LOG(HER)
Norm. PSF Weights	0.111	0.111	0.222	0.111	0.111	0.222	0.111	1			
	PSF RANKINGS										
MAX HER	10	10	10	10	10	10	10		10	1.54E-01	-8.13E-01
ZHEOS1	1	7	7	6	9	2	4		5	9.15E-03	-2.04E+00
ZHEOS2	1	8	8	8	9	2	5		5.6667	1.33E-02	-1.88E+00
ZHEOS3	1	8	8	8	9	5	7		6.5556	2.20E-02	-1.66E+00
ZHEOS4	1	8	8	8	9	8	8		7.3333	3.41E-02	-1.47E+00
ZHESL4	2	8	8	9	9	7	8		7.3333	3.41E-02	-1.47E+00
ZHEXT2	8	9	10	1	4	9	9		7.6667	4.12E-02	-1.39E+00
ZHEXT4	8	9	10	5	4	9	9		8.1111	5.29E-02	-1.28E+00
MIN HER	0	0	0	0	0	0	0		0	5.44E-04	-3.26E+00

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	5.00E-01	-3.01E-01
DC ZHEOS1	2	2	1	5	5	3	4	2.8889	1.50E-03	-2.82E+00
EPRI L1 (1)	1	8	8	8	9	4	5	6.1111	2.00E-03	-2.70E+00
STP HEOR07	7	5	5	4	5	6	6	5.4444	2.08E-02	-1.68E+00
MIN HER	0	0	0	0	0	0	0	0	1.50E-03	-2.82E+00

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEOS2)

Regression Output:

Constant	-3.264095629
Std Err of Y Est	0.69738723
R Squared	0.69679788
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	0.245075073
Std Err of Coef.	0.093336437

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION: RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHEOS1	5	5	10	5	5	10	5	45	7.5	4.32E-03
ZHEOS2	5	5	10	5	5	10	5	45	5	8.26E-03
ZHEOS3	5	5	10	5	5	10	5	45	5	1.36E-02
ZHEOS4	5	5	10	5	5	10	5	45	5	2.11E-02
ZHESL4	5	5	10	5	5	10	5	45	5	2.11E-02
ZHEXT2	5	5	10	5	5	10	5	45	5	2.55E-02
ZHEXT4	5	5	10	5	5	10	5	45	5	3.28E-02
NORMALIZED PSF WEIGHTS	0.111	0.111	0.222	0.111	0.111	0.222	0.111	1		

Figure 17: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 2

BEAVER VALLEY UNIT 2 - GROUP 3 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.111	0.056	0.111	0.111	0.167	0.222	0.222	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	2.16E-01	-6.66E-01
ZHEFL2	4	1	8	5	10	8	8	7.1667	6.70E-02	-1.17E+00
ZHERE6	1	2	8	9	9	7	7	6.7222	5.58E-02	-1.25E+00
MIN HER	0	0	0	0	0	0	0	0	3.47E-03	-2.46E+00
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.00E+00
STP HEOS01	6	4	6	3	10	10	3	6.4444	1.80E-02	-1,74E+00
FERM RE7	6	7	6	8	6	5	8	6.50	1.32E-02	-1.88E+00
MIN HER	0	0	0	0	0	0	0	0	8.00E-03	-2.10E+00

Regression Output:

Constant	-2.45904629
Std Err of Y Est	0.74586100
R Squared	0.60132401
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.179351546
Std Err of Coef.	0.10326328

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
	PSF WEIGHTS							
ZHEFL2	5	0	5	5	10	10	10	45
ZHERE6	5	5	5	5	5	10	10	45
NORMALIZED PSF WEIGHTS	0.111	0.056	0.111	0.111	0.167	0.222	0.222	1

INPUT TO RISKMAN FOR HER DISTRIBUTION

	RANGE FACTOR	MEDIAN
ZHEFL2	5	4.15E-02
ZHERE6	5	3.46E-02

Figure 18: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 3

BEAVER VALLEY UNIT 2 - ACTION GROUP 4 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.125	0.125	0.125	0.125	0.125	0.125	0.25	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.76E-01	-7.56E-01
ZHEMU1	2	4	8	4	6	3	8	5.38	5.97E-03	-2.22E+00
ZHEMU2	2	4	8	4	6	1	8	5.13	4.97E-03	-2.30E+00
ZHEMU3	2	4	8	4	6	7	8	5.88	8.60E-03	-2.07E+00
ZHEMU4	2	4	8	4	6	9	8	6.13	1.03E-02	-1.99E+00
ZHEWM1	2	5	8	6	6	0	8	5.38	5.97E-03	-2.22E+00
MIN HER	0	0	0	0	0	0	0	0	1.17E-04	-3.93E+00
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E-01	-1.00E+00
STP HERC4	3	2	1	8	5	6	6	4.625	9.82E-04	-3.01E+00
TMI HLTIB (1)	2	4	8	4	6	4	8	5.50	6.24E-02	-1.20E+00
FERMI HECT3	4	6	3	3	3	3	3	3.50	1.15E-03	-2.94E+00
MIN HER	0	0	0	0	0	0	0	0	1.00E-04	-4.00E+00

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEMU2)

Regression Output:

Constant	-3.93053070
Std Err of Y Est	0.66739322
R Squared	0.79766860
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	0.317487722
Std Err of Coef.	0.092318066

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION	
OPERATOR ACTIONS	PSF WEIGHTS								RANGE FACTOR	MEDIAN
ZHEMU1	5	5	5	5	5	5	10	40	7.5	2.82E-03
ZHEMU2	5	5	5	5	5	5	10	40	7.5	2.35E-03
ZHEMU3	5	5	5	5	5	5	10	40	7.5	4.06E-03
ZHEMU4	5	5	5	5	5	5	10	40	5	6.40E-03
ZHEWM1	5	5	5	5	5	5	10	40	7.5	2.82E-03
NORMALIZED PSF WEIGHTS	0.125	0.125	0.125	0.125	0.125	0.125	0.25	1		

Figure 19: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 4

BEAVER VALLEY UNIT 2 - ACTION GROUP 5 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.145	0.145	0.14	0.145	0.14	0.14	0.145	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.75E-01	-1.12E-02
ZHEAF2	2	3	3	2	2	0	2	2.01	3.36E-04	-3.47E+00
ZHEAF3	2	3	3	2	2	0	2	2.01	3.36E-04	-3.47E+00
ZHECC1	2	6	6	7	2	2	5	4.30	3.31E-03	-2.48E+00
ZHECC2	2	6	7	7	2	4	6	4.87	5.82E-03	-2.24E+00
ZHECD1	2	4	3	3	2	3	4	3.01	9.10E-04	-3.04E+00
ZHECD2	2	5	8	5	6	3	4	4.70	4.93E-03	-2.31E+00
ZHECI2	1	2	4	1	3	3	3	2.42	5.05E-04	-3.30E+00
ZHECS1	3	7	7	7	7	6	6	6.14	2.06E-02	-1.69E+00
ZHEFL1	2	7	6	4	7	1	3	4.28	3.25E-03	-2.49E+00
ZHEHH1	1	7	5	5	2	4	6	4.30	3.29E-03	-2.48E+00
ZHEHH2	2	2	3	1	3	3	4	2.57	5.87E-04	-3.23E+00
ZHEMA2	2	6	5	3	8	5	6	4.99	6.56E-03	-2.18E+00
ZHEOB1	5	3	5	3	3	1	6	3.73	1.87E-03	-2.73E+00
ZHEOD1	2	3	5	2	5	0	5	3.14	1.04E-03	-2.98E+00
ZHEOF1	2	4	5	2	3	1	5	3.15	1.05E-03	-2.98E+00
ZHEOF2	2	1	1	2	2	0	5	1.87	2.93E-04	-3.53E+00
ZHEOR1	2	3	5	3	4	2	5	3.43	1.38E-03	-2.86E+00
ZHEOR2	2	3	5	3	4	5	5	3.85	2.10E-03	-2.68E+00
ZHEOS5	1	4	2	2	4	2	5	2.86	7.88E-04	-3.10E+00
ZHEPI1	0	0	1	5	3	2	5	2.29	4.46E-04	-3.35E+00
ZHERE5	1	2	8	9	9	2	5	5.13	7.54E-03	-2.12E+00
ZHERED	1	2	2	6	2	1	2	2.30	4.48E-04	-3.35E+00
ZHERR1	2	2	5	5	4	2	2	3.14	1.04E-03	-2.98E+00
ZHERR2	2	2	5	5	4	2	2	3.14	1.04E-03	-2.98E+00
ZHESE2	2	7	1	2	5	1	2	2.87	7.92E-04	-3.10E+00
ZHESE5	5	4	5	2	7	1	5	4.14	2.82E-03	-2.55E+00
ZHESL2	3	2	8	5	4	0	8	4.29	3.28E-03	-2.48E+00
ZHESL3	7	10	9	9	10	0	10	7.88	1.18E-01	-9.29E-01
ZHETB1 (IC1)	2	7	1	2	5	1	2	2.87	7.92E-04	-3.10E+00
MIN HER	0	0	0	0	0	0	0	0	4.55E-05	-4.34E+00

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION	
OPERATOR ACTIONS	PSF WEIGHTS								RANGE FACTOR	MEDIAN
ZHEAF2	5	5	5	5	5	5	5	35	10	1.26E-04
ZHEAF3	5	5	5	5	5	5	5	35	10	1.26E-04
ZHECC1	5	5	5	5	5	5	5	35	7.5	1.56E-03
ZHECC2	5	5	5	5	5	5	5	35	7.5	2.75E-03
ZHECD1	5	5	5	5	5	5	5	35	10	3.42E-04
ZHECD2	5	5	5	5	5	5	5	35	7.5	2.33E-03
ZHECI2	5	5	5	5	5	5	5	35	10	1.90E-04
ZHECS1	5	5	5	5	5	5	5	35	5	1.28E-02
ZHEFL1	5	5	5	5	0	0	5	25	7.5	1.53E-03
ZHEHH1	5	5	5	5	5	5	5	35	7.5	1.56E-03
ZHEHH2	5	5	5	5	5	5	5	35	10	2.20E-04
ZHEMA2	5	5	5	5	5	5	5	35	7.5	3.10E-03
ZHEOB1	5	5	5	5	5	5	5	35	7.5	8.81E-04
ZHEOD1	5	5	5	5	5	5	5	35	7.5	4.92E-04
ZHEOF1	5	5	5	5	5	5	5	35	7.5	4.94E-04
ZHEOF2	5	5	5	5	5	5	5	35	10	1.10E-04
ZHEOR1	5	5	5	5	5	5	5	35	7.5	6.53E-04
ZHEOR2	5	5	5	5	5	5	5	35	7.5	9.93E-04
ZHEOS5	5	5	0	5	5	5	5	30	10	2.96E-04
ZHEPI1	5	5	5	5	5	5	5	35	10	1.67E-04
ZHERE5	5	5	5	5	5	5	5	35	7.5	3.56E-03
ZHERED	5	5	5	5	5	5	5	35	10	1.68E-04
ZHERR1	5	5	5	5	5	5	5	35	7.5	4.89E-04
ZHERR2	5	5	5	5	5	5	5	35	7.5	4.89E-04
ZHESE2	5	5	5	5	5	5	5	35	10	2.97E-04
ZHESE5	5	5	5	5	5	5	5	35	7.5	1.33E-03
ZHESL2	5	5	5	5	5	5	5	35	7.5	1.55E-03
ZHESL3	5	5	5	5	5	5	5	35	3	9.41E-02
ZHETB1	5	5	5	5	5	5	5	35	7.5	3.74E-04
NORMLAIZED PSF WEIGHTS	0.145	0.145	0.14	0.145	0.14	0.14	0.145	1		

Figure 20: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 5

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.00E-01	-4.58E-02
TMI HSR1 (1)	2	3	5	3	4	5	5	3.65	4.74E-02	-1.32E+00
TMI HSR2 (2)	2	3	5	3	4	2	5	3.43	1.27E-04	-3.90E+00
STP HEOD03	6	6	6	5	6	8	9	6.57	4.36E-02	-1.36E+00
TMI HCD1 (3)	2	4	3	3	2	3	4	3.01	1.27E-04	-3.90E+00
STP HEOSL1	5	3	4	3	3	3	6	3.87	2.13E-03	-2.67E+00
STP HEOC01	6	3	2	3	4	4	4	3.72	2.31E-03	-2.64E+00
MIN HER	0	0	0	0	0	0	0	0	1.00E-04	-4.00E+00

NOTES:
(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEOR1)
(2) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEOR2)
(3) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHECD1)

Regression Output:	
Constant	-4.34244300
Std Err of Y Est	0.792487245
R Squared	0.747130953
No. of Observations	8
Degrees of Freedom	6
X Coefficient(s)	0.433127309
Std Err of Coef.	0.10287016

Figure 20 (Cont.): BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 5

BEAVER VALLEY UNIT 2 - ACTION GROUP 6 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
PSF Weights	0.143	0.143	0.143	0.143	0.143	0	0.286	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	3.74E-01	-4.27E-01
ZHEOA1	2	0	2	0	3	2	7	3.00	3.84E-03	-2.42E+00
MIN HER	0	0	0	0	0	0	0	0	5.39E-04	-3.27E+00
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	5.00E-01	-3.01E-01
DC ZHECE1 (1)	2	0	2	0	3	2	7	3.00	1.70E-03	-2.77E+00
FERM HERBI2	3	4	3	3	5	5	8	4.86	1.18E-02	-1.93E+00
MIN HER	0	0	0	0	0	0	0	0	1.00E-03	-3.00E+00

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEOA1)

Regression Output:

Constant	-3.2683E+00
Std Err of Y Est	3.2749E-01
R Squared	9.5216E-01
No. of Observations	4
Degrees of Freedom	2.0000000
X Coefficient(s)	0.284162745
Std Err of Coef.	0.045039069

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRUBITION: RANGE FACTOR	MEDIAN
OPERATOR ACTIONS	PSF WEIGHTS									
ZHEOA1	5	5	5	5	5	0	10	35	7.5	1.81E-03
NORMALIZED PSF WEIGHTS	0.143	0.143	0.143	0.143	0.143	0.00	0.286	1		

Figure 21: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 6

BEAVER VALLEY UNIT 2 - ACTION GROUP 7 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm. PSF Weights	0.12	0.24	0.14	0.12	0.12	0.12	0.14	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	5.29E-01	-2.76E-01
ZHECD5	1	5	8	5	6	2	8	5.08	1.84E-02	-1.74E+00
ZHECI1	1	5	7	3	2	5	2	3.77	7.52E-03	-2.12E+00
ZHEIA2	3	7	2	2	2	5	6	4.24	1.04E-02	-1.98E+00
ZHEIA3	3	8	7	9	9	9	6	7.35	8.67E-02	-1.06E+00
ZHEOB2	5	9	5	3	3	2	8	5.53	2.49E-02	-1.60E+00
ZHESE3	2	9	1	2	5	1	6	4.35	1.12E-02	-1.95E+00
ZHESE4	2	9	2	2	7	1	6	4.73	1.45E-02	-1.84E+00
ZHETB2	2	9	1	2	5	1	6	4.35	1.12E-02	-1.95E+00
ZHETB3	2	9	2	2	7	1	6	4.73	1.45E-02	-1.84E+00
MIN HER	0	0	0	0	0	0	0	0	5.73E-04	-3.24E+00

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.00E+00
STP HEOB02	6	4	2	3	4	7	8	4.76	8.80E-03	-2.06E+00
OPRA-8 (1)	5	9	5	3	3	7	6	5.86	1.00E-02	-2.00E+00
DC ZHEOB1	7	5	4	7	6	6	8	6.00	5.49E-02	-1.26E+00
MIN HER	0	0	0	0	0	0	0	0	1.00E-03	-3.00E+00

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEOB2)

Regression Output:	
Constant	-3.242184576
Std Err of Y Est	0.396998645
R Squared	0.90510960
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	0.29657300
Std Err of Coef.	0.055441061

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	INPUT TO RISKMAN FOR HER DISTRIBUTION: RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHECD5	5	10	5	5	5	5	10	45	5	1.14E-02
ZHECI1	5	10	10	5	5	5	5	45	7.5	3.55E-03
ZHEIA2	5	10	5	5	5	5	5	40	5	6.43E-03
ZHEIA3	5	10	5	5	5	5	5	40	5	5.37E-02
ZHEOB2	5	10	5	5	5	5	5	40	5	1.55E-02
ZHESE3	5	10	5	5	5	5	5	40	5	6.92E-03
ZHESE4	5	10	5	5	5	5	5	40	5	8.97E-03
ZHETB2	5	10	5	5	5	5	5	40	5	6.92E-03
ZHETB3	5	10	5	5	5	5	5	40	5	8.97E-03
NORMALIZED PSF WEIGHTS	0.122	0.243	0.135	0.122	0.122	0.122	0.135	1		

Figure 22: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 7

BEAVER VALLEY UNIT 2 - ACTION GROUP 8 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PROCEDURES	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	FLI	HER	LOG(HER)
Norm. PSF Weights	0.128	0.128	0.128	0.116	0.116	0.256	0.128	1			
	PSF RANKINGS										
MAX HER	10	10	10	10	10	10	10		10	3.53E-01	-4.53E-01
ZHECD3	2	3	3	2	2	0	5		2.13	1.21E-03	-2.92E+00
ZHECD4	2	5	8	5	6	4	7		5.12	1.04E-02	-1.98E+00
ZHEIA1	1	3	2	5	2	7	3		3.76	3.91E-03	-2.41E+00
ZHEOT1	1	0	1	0	0	5	6		2.30	1.37E-03	-2.86E+00
ZHEREE	1	2	2	6	2	4	5		3.23	2.68E-03	-2.57E+00
ZHERI1	1	0	1	0	0	5	7		2.43	1.51E-03	-2.82E+00
ZHESE1	2	4	2	1	4	7	5		4.03	4.79E-03	-2.32E+00
ZHESL1	2	1	5	2	3	4	6		3.40	3.02E-03	-2.52E+00
ZHESL5	2	4	5	2	4	8	8		5.17	1.09E-02	-1.96E+00
ZHEWA2	2	3	7	4	2	5	5		4.15	5.20E-03	-2.28E+00
ZHEWA4	2	6	7	7	10	5	6		5.94	1.89E-02	-1.72E+00
MIN HER	0	0	0	0	0	0	0		0	2.61E-04	-3.58E+00

CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.00E+00
STP HEOSL1	5	3	4	3	3	3	6	3.77	2.13E-03	-2.67E+00
FERMI HERS1	2	7	2	3	2	4	6	3.78	1.75E-03	-2.76E+00
STP HEOS01	6	4	6	3	10	10	3	6.50	1.80E-02	-1.74E+00
DC ZHEOX1 (1)	2	1	5	2	3	7	6	4.16	3.20E-03	-2.49E+00
MIN HER	0	0	0	0	0	0	0	0	1.00E-03	-3.00E+00

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHESL1)

Regression Output:

Constant	-3.583059682
Std Err of Y Est	0.455189634
R Squared	0.867599013
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	0.31302434
Std Err of Coef.	0.061141234

PERFORMANCE SHAPING FACTORS

INPUT TO RISKMAN FOR HER DISTRIBUTION

OPERATOR ACTIONS	INTERFACE	PROCEDURES	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM	RANGE FACTOR	MEDIAN
	PSF WEIGHTS									
ZHECD3	5	5	5	5	5	10	5	40	7.5	5.72E-04
ZHECD4	5	5	5	5	5	10	5	40	5	6.47E-03
ZHEIA1	5	5	5	5	5	10	5	40	7.5	1.85E-03
ZHEOT1	5	5	5	0	5	10	5	35	10	5.15E-04
ZHEREE	5	5	5	5	5	10	5	40	7.5	1.27E-03
ZHERI1	5	5	5	5	5	10	5	40	7.5	7.11E-04
ZHESE1	5	5	5	5	5	10	5	40	7.5	2.26E-03
ZHESL1	5	5	5	5	5	10	5	40	7.5	1.43E-03
ZHESL5	5	5	5	5	5	10	5	40	5	6.74E-03
ZHEWA2	5	5	5	5	0	10	5	35	7.5	2.46E-03
ZHEWA4	5	5	5	5	5	10	5	40	5	1.17E-02
NORMALIZED PSF WEIGHTS	0.128	0.128	0.128	0.116	0.116	0.256	0.128	1		

Figure 23: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 8

BEAVER VALLEY UNIT 2 - ACTION GROUP 9 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm PSF Weights	0	0.176	0.176	0.176	0.176	0.118	0.176	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	6.28E-01	-2.02E-01
ZHEOD6	2	9	3	3	7	3	9	5.82	7.65E-02	-1.12E+00
ZHEOD7	2	9	8	5	8	4	9	7.35	1.66E-01	-7.82E-01
ZHEWA6	2	4	5	4	5	2	1	3.59	2.48E-02	-1.61E+00
MIN HER	0	0	0	0	0	0	0	0.00	4.05E-03	-2.39E+00
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.00E+00
STP HEOD03	6	6	6	5	6	8	9	6.5882	4.38E-02	-1.36E+00
EPRI SH1 (1)	2	9	3	3	7	3	9	5.8235	1.00E-01	-1.00E+00
MIN HER	0	0	0	0	0	0	0	0	5.00E-03	-2.30E+00

NOTE:

(1) RANKINGS ARE THOSE FOR SIMILAR ACTION IN BV2 (ZHEOD6)

Regression Output:

Constant	-2.392031371
Std Err of Y Est	0.339302955
R Squared	0.9151131
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.219017541
Std Err of Coef.	0.047167948

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
	PSF WEIGHTS							
ZHEOD6	0	5	5	5	5	5	5	30
ZHEOD7	0	5	5	5	5	5	5	30
ZHEWA6	0	5	5	5	5	0	5	25
MORMALIZED PSF WEIGHTS	0	0.176	0.176	0.176	0.176	0.118	0.176	1

INPUT TO RISKMAN FOR HER DISTRIBUTION

	RANGE FACTOR	MEDIAN
ZHEOD6	5	4.74E-02
ZHEOD7	3	1.32E-01
ZHEWA6	5	1.53E-02

Figure 24: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 9

BEAVER VALLEY UNIT 2 - GROUP 10 HUMAN ACTIONS EVALUATION

PERFORMANCE SHAPING FACTORS

	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM		
Norm PSF Weights	0.14	0.14	0.29	0.00	0.14	0.14	0.14	1		
OPERATOR ACTIONS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	9.96E-01	-1.78E-03
ZHEXT1	8	9	10	1	4	4	8	7.57	2.89E-02	-1.54E+00
MIN HER	0	0	0	0	0	0	0	0.00	4.67E-07	-6.33E+00
CALIBRATION TASKS	PSF RANKINGS							FLI	HER	LOG(HER)
MAX HER	10	10	10	10	10	10	10	10	1.00E+00	0.0000
SEABROOK ON	0	0	1	0	2	0	0	0.5714	1.00E-06	-6.0000
MIN HER	0	0	0	0	0	0	0	0	5.00E-07	-6.3010

Regression Output:

Constant	-6.33E+00
Std Err of Y Est	4.29E-02
R Squared	0.999927115
No. of Observations	3
Degrees of Freedom	1
X Coefficient(s)	0.632866998
Std Err of Coef.	0.005403158

PERFORMANCE SHAPING FACTORS

OPERATOR ACTIONS	INTERFACE	PRECEDING	COMPLEXITY	PROCEDURES	TRAINING	TIME	STRESS	SUM
	PSF WEIGHTS							
ZHEXT1	5	5	10	0	5	5	5	35
NORMALIZED PSF WEIGHTS	0.14	0.14	0.29	0.00	0.14	0.14	0.14	1

INPUT TO RISKMAN FOR HER DISTRIBUTION

RANGE FACTOR	MEDIAN
5	1.79E-02

Figure 25: BVPS-2 Pre-EPU Sensitivity Model SLIM Worksheet Group 10